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AN AUTORANGING BALLOON ALTIMETER: A SINGLE PRESSURE TRANSDUCER --ETC(U)
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An Autoranging Balloon Altimeter: A Single Pressure Transducer Monitors Altitude From 0 to 44 Kilometers With 30 Meters Resolution

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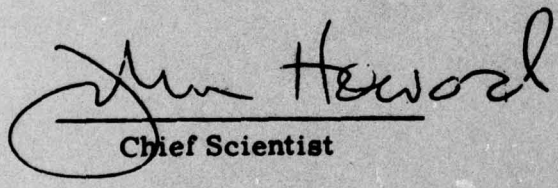

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This report documents a method of determining altitude based on the atmospheric pressure using the U. S. Standard Atmosphere, 1976 to model the pressure vs altitude profile. A precision pressure transducer facilitates the design, which is described in increasing levels of completeness from the basic block diagram to "as built" schematics and pictures. The design algorithm, supporting firmware and software, is presented and explained. Test results confirm the design calculations and validate the altimeter's accuracy and resolution.

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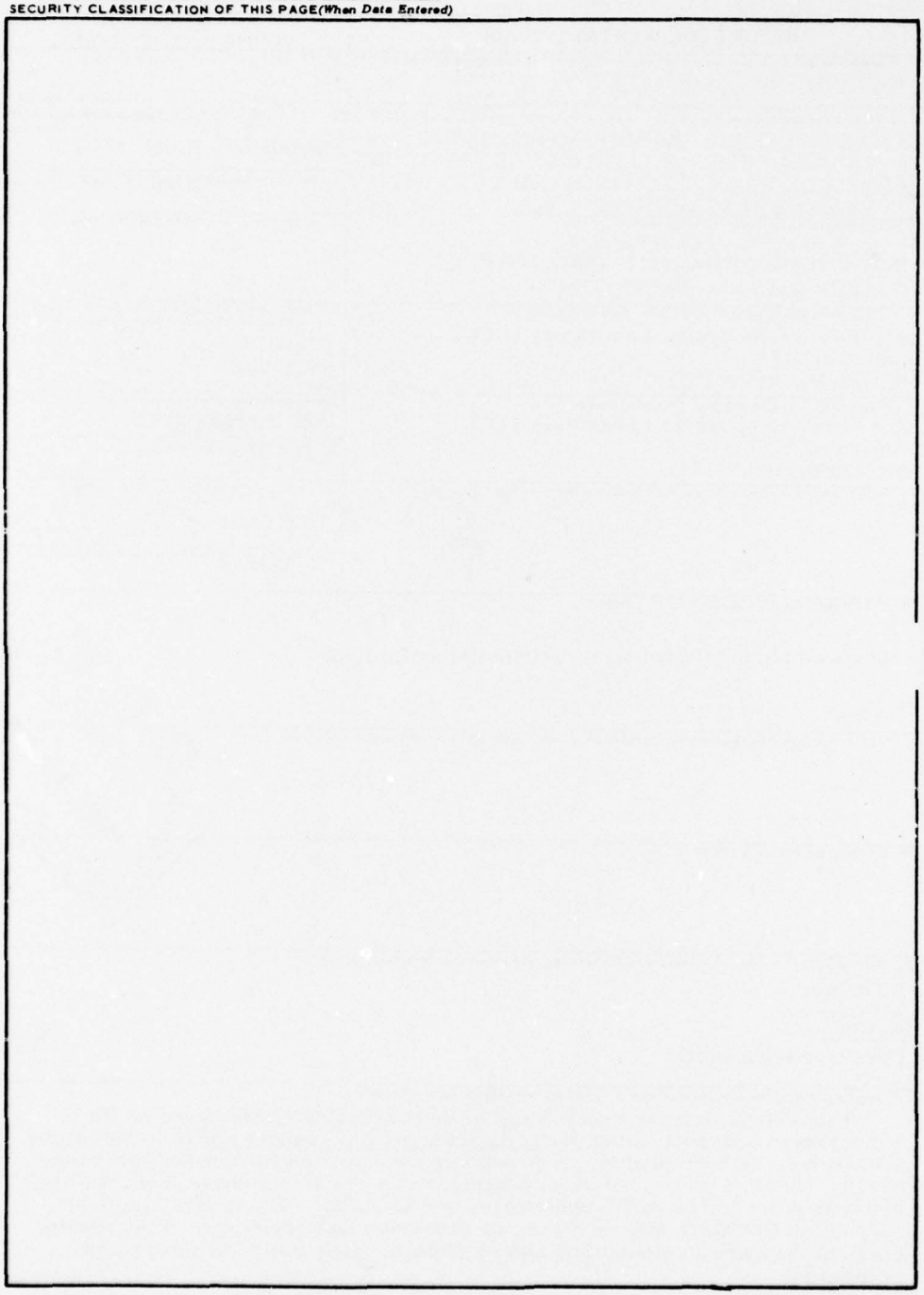

Preface

The altimeter described within necessarily uses a certain sensor to obtain the results reported. However, this report is not endorsing that sensor but rather describing a means of using any sensor with a similar output signal.

The author expresses his thanks to Mssrs. J. Dwyer and H. Laping for the contributions noted. He also is indebted to Mr. R. Cowie, Lt. L. Wrinkle, and Mrs. C. Rice for their constructive remarks and suggestions on the first draft; and to Ms. M. Cross for typing the manuscript.

Contents

Contents

Illustrations

Illustrations

Tables

An Autoranging Balloon Altimeter: A Single Pressure Transducer Monitors Altitude From 0 to 44 Kilometers With 30 Meters Resolution

1. INTRODUCTION

The purpose of this report is to document the use of a single pressure sensor as an altimeter for balloon borne scientific experiments in the altitude range 0 to 44 m (145 k ft). The report describes the development of an algorithm to facilitate use of the sensor, and the fabrication of an interface device to perform the algorithm. The sensor and interface operate into an existing frequency-sensitive encoder with a commutator segment aperture time of 2 sec.

2. THE SENSOR

The Model-1D Digital Pressure Transducer by Hamilton Standard[1] is a small, lightweight sensor with a variable frequency output. The calibration error is ±0.008 percent of full scale (FS) and the repeatability error is ±0.0001 percent FS. Since full scale pressure is 20.0 psia, the absolute calibration error, E, is 0.0032 psia. To relate this pressure error to altitude error, we chose to define the dependence of atmospheric pressure upon altitude by

(Received for publication 24 January 1978)

1. Hamilton Standard Instruction Manual: The Hamilton Standard Model 1D Digital Pressure Transducer (P/N 752200), Windsor Locks, Connecticut.

$$P = P_o \varepsilon^{\alpha A} \tag{1}$$

where P is pressure in psia, P_o is 14.696 psia, α is a constant equal to -0.044011/k ft when A is altitude in k ft. This is a very good approximation of the atmosphere as defined in the U.S. Standard Atmosphere 1976.[2] Eq. (1) is much easier to work with than the altitude "shells" defined in reference 2, computational equations section. Differentiating Eq. (1) yields

$$r = \frac{dP}{dA} = r_o \varepsilon^{\alpha A} \tag{2}$$

where r is the rate of change in psia/ft and r_o equals -0.000646786 psia/ft. Therefore, the absolute error in feet, E', is defined as

$$E' = E/r. \tag{3}$$

Table 1 was generated using Eq. (3), and shows that this sensor fits our requirements very well. However, Table 2 and Figure 1 show that the output rate of change decreases rapidly with increasing altitude. Therefore, some manipulation is required to maximize the sensor's utility.

Table 1. Sensor Error

Altitude		Absolute Error	
km	(k ft)	ft	m
0	0	4.95	1.51
6.1	20	11.9	3.64
12.2	40	28.8	8.77
18.3	60	69.4	21.1
24.4	80	167	51.0
30.5	100	403	123
36.6	120	973	297
42.7	140	2346	715

2. U.S. Standard Atmosphere (1976), NOAA, NASA, USAF, Washington, D.C.

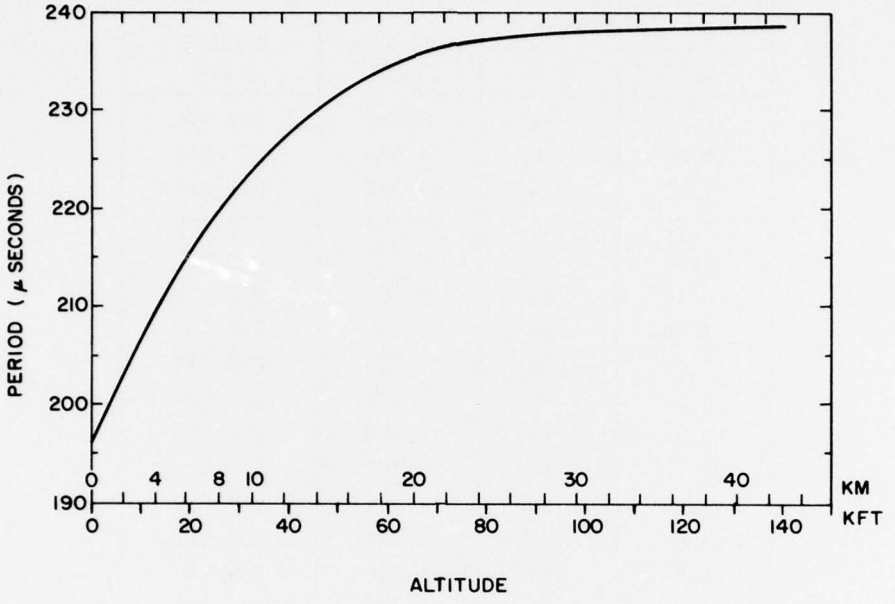

Figure 1. Sensor Output: Period vs Altitude

The manufacturer defines the sensor in terms of two equations. The first equation

$$Y = B_o + B_1 x \quad ,$$

produces a dummy variable Y as a function of x, the output period in microseconds. The second equation

$$P = A_o + A_1 Y + A_2 Y^2 + A_3 Y^3 + A_4 Y^4$$

defines the pressure (psia) as a function of the dummy variable. Table 2 was generated using the vender's tables for the sensor at hand and pressures from the U. S. Standard Atmosphere 1976. Periods were calculated via linear interpolation for those pressure values.

Table 2. Sensor Output (Preliminary)

Altitude		Pressure	Period
km	k ft	psia	μ sec
-0.30	-1	15.234	194.954
0.00	0	14.696	196.043
1.52	5	12.228	201.329
3.05	10	10.108	206.298
4.57	15	8.297	210.911
6.10	20	6.758	215.140
7.62	25	5.460	218.964
9.14	30	4.372	222.374
10.7	35	3.467	225.373
12.2	40	2.730	227.939
13.7	45	2.148	230.052
15.2	50	1.691	231.770
16.8	55	1.331	233.165
18.3	60	1.048	234.288
19.8	65	0.825	235.188
21.3	70	0.650	235.908
22.9	75	0.512	236.479
24.4	80	0.403	236.938
25.9	85	0.318	237.300
27.4	90	0.251	237.583
29.0	95	0.200	237.804
30.5	100	0.160	237.974
32.0	105	0.128	238.113
33.5	110	0.103	238.222
35.1	115	0.0840	238.304
36.6	120	0.0683	238.373
38.1	125	0.0557	238.427
39.6	130	0.0456	238.471
41.1	135	0.0375	238.507
42.7	140	0.0309	238.535
44.2	145	0.0255	238.559

3. THE ALGORITHM

Prior to discussing the proposed algorithm, two constraints must be considered. First, the altitude resolution corresponding to ±1/2 bit error of the binary interface, should be approximately 30 m (100 ft) worse case. Second, the data must fit the twelve bit register in the aforementioned encoder. These twelve bits correspond to 4096 states or eight 512 state ranges. The reason for this will become evident as the discussion continues.

It was decided to multiply and measure the period rather than multiply and measure the frequency. This approach was taken because it has two strong positive points. First, it is easier to accomplish with the technology chosen for device fabrication. Second, it is easier to achieve a uniform pulse rate which facilitates a uniform predictable error (resolution) at any given sensor frequency.

In general terms, the algorithm is based on the fact that an unknown period can be measured by gating a known reference frequency by that period while counting the number of events which occur. The resulting count is a measure of the period with an error of one event. Therefore, enlarging (by multiplying) the unknown period to increase the number of events of the reference oscillator occurring in the unknown time, produces a large count which reduces the relative measurement error. The only drawback with this scheme is that the large constant portion of the sensor period (approximately 190 μsec) is multiplied along with the changing period (approximately 50 μsec) which contains the information. Rather than transmit this unchanging, known and therefore informationless number of events, it will be removed by subtraction. Figure 2 is a block diagram of the algorithm.

The principal functions are in line under the sensor block; multiply the output period (by 2^n), measure the resulting period, and subtract the known part of the count. After subtraction, the remainder will be less than 512 events of altitude information for any scale. As indicated earlier, 4096 events are eight 512 event subsets; and as may be surmised from Figure 2, one coefficient for the period multiplier will not suffice, nor will one subtrahend for the subtractor. Therefore, a mechanism to change these constants (that is, constants within each range) must be supplied; this is the scale selector.

Without considering how it will be accomplished, Table 3 lists events vs altitude for each scale. The multiplier $2^n \times 10^6$ is a combination of the period multiplier 2^n (unitless) with the product modulator 10^6 (events/sec).

Note that the resolution varies from about 17 m (55 ft) to 32 m (105 ft) per scale; and there is plenty of overlap in the ranges. By this, I mean that the "6" scale could be used for altitudes over 130 k ft even though the instrument is supposed to be switched to the "7" scale by that point. And, the "7" scale is functional below 120 k ft event through it is supposed to be used from 125 to 145 k ft.

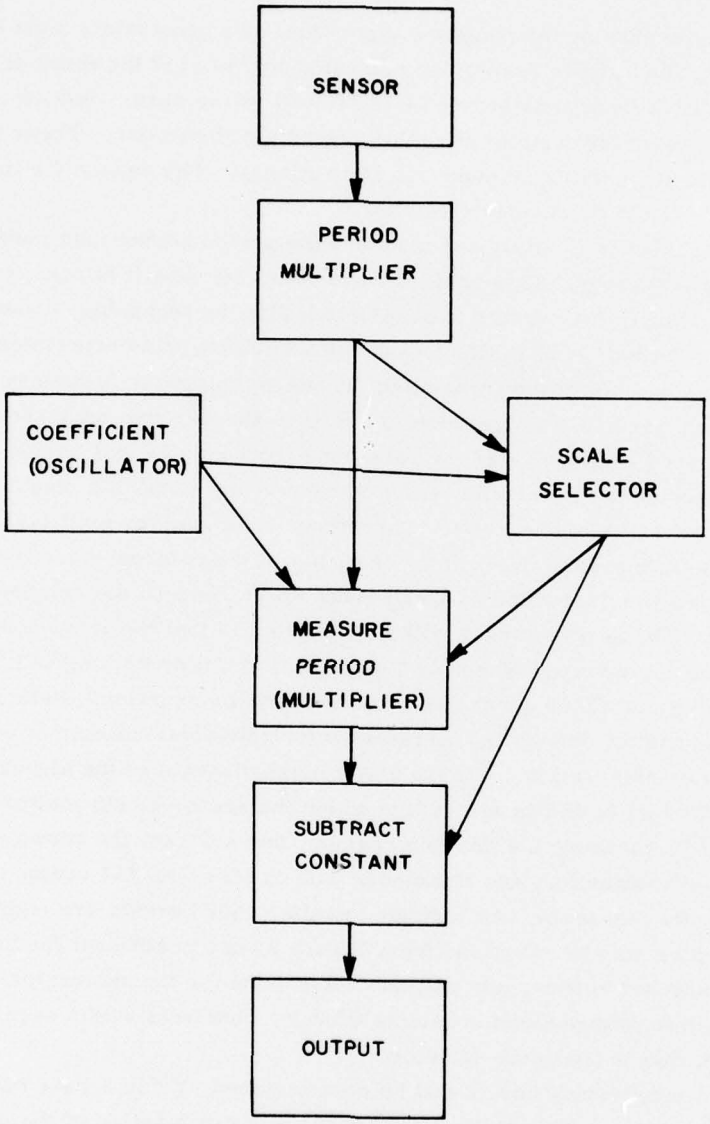

Figure 2. Algorithm Flow Diagram

Table 3. Data Summary (Preliminary)

Scale	alt	p × multiplier = events		Δ	Resolution	Remaining Counts
	k ft	μ sec	$2^n \times 10^6$	events	ft	
	-1		3119	17	58	19
	0	n = 4	3136	84	59	36
0	5	subtrahend: 3100	3221			121
	25		3503	54	91	403
	30		3557	47	104	457
	35		3605	41	121	505
	40		3647			
	30		7115	96	52	115
	35	n = 5	7211	82	60	211
1	40	subtrahend: 7000	7294	67	73	294
	45		7361	54	90	361
	50		7416	44	112	416
	55		7461			461
	50		14833	89	56	83
	55	n = 6	14922	71	69	172
2	60	subtrahend: 14750	14994	57	86	244
	65		15052	46	108	302
	70		15098	36	136	348
	75		15134			
	65		30 104	92	54	104
	70	n = 7	30 196	73	68	196
3	75	subtrahend: 30 000	30 269	58	85	269
	80		30 328	46	107	328
	85		30 374			374
	80		60 656	91	54	156
	85	n = 8	60 748	72	69	248
4	90	subtrahend: 60500	60 821	56	88	321
	95		60 877	43	114	377
	100		60 921		140	421
	105		60 956			
	95		121 755	86	58	155
	100	n = 9	121 842	71	70	242
5	105	subtrahend: 121, 600	121 913	55	89	313
	110		121 969	41	119	369
	115		122 011			411

Table 3. Data Summary (Preliminary) (Cont.)

Scale	alt	p × multiplier = events		Δ	Resolution	Remaining Counts
	k ft	μ sec	$2^n \times 10^6$	events	ft	
6	110	n = 10 subtrahend: 243,800	243 939	83	59	139
	115		244 023	70	70	223
	120		244 093	55	90	293
	125		244 149	45	110	349
	130		244 194			394
7	120	n = 11 subtrahend: 488,100	488 187	111	45	87
	125		488 298	90	55	198
	130		488 388	73	67	288
	135		488 462	57	87	362
	140		488 519	49	101	419
	145		488 586			468

After calculation of the events and the resolution, the subtrahend is chosen to place the counts remaining in the range of 0 to 512 for each scale.

How does the scale selector work and what is its switching resolution? Figure 2 shows that the scale selector has inputs from the period multiplier and the reference oscillator. The product (sensor period x multiplier x coefficient) is formed and then compared to several predetermined products which are defined as switching points. The most significant point to be detected determines the scale to be used. Table 4 lists the switching points and resolution. The resolution was computed by determining the data count for a point on either side of the switching point, finding the difference, and dividing the altitude difference by the count difference. A worse case example shows that in the vicinity of a switching point, usable data are available on both scales. Note that at 125 k ft, the resolution is 304.8 m (1000 ft)*; on Table 3 it can be seen that this corresponds to 9 counts above 125 k ft in scale "6" or 22 counts below 125 k ft in scale "7". There is plenty of room in the event counter to accommodate this resolution.

One loose end, differentiating between scales, remains. Recall that the data have been confined to 512 events, while the data counter in the encoder accommodates 4096 (8 × 512) states. The data counter's output are a twelve binary bit word which is arranged in four, 3 bit groups to facilitate recording and decoding. Nine bits define 512 states (0 through 511 events). Since the data remain below 512

*This is an exact definition from reference 2.

Table 4. Scale Selector Switching Point Resolution

Altitude		Pressure	Period	Multiplier		Resolution
k ft		psia	μ sec	$2^7 \times 10^6$	Δ	ft
30	29.5	4.472	222.052	28422	82	12
	30.5	4.274	222.690	28504		
50	49.5	1.732	231.615	29646	40	25
	50.5	1.651	231.923	29686		
65	64.5	0.845	235.108	30093	13	48
	65.5	0.806	235.267	30114		
80	79.5	0.413	236.900	30323	9	111
	80.5	0.394	236.975	30332		
95	94.5	0.205	237.781	30435	5	200
	95.5	0.196	237.819	30440		
110	109.0	0.108	238.200	30489	5	400
	111.0	0.0995	238.237	30494		
125	124.0	0.0580	238.417	30517	2	1000
	126.0	0.0535	238.437	30519		

events, the most significant three bits are never used; or, they always read ØØØ. If 512 events were added to the data, the most significant three bits would contain ØØ1. Note that this set of bits has now uniquely defined two scales: a Ø scale, and a 1 scale. If integer multiples of 512 (1024, 1536, 2048, etc.) are added to the data, more scales (2, 3, 4, etc.) are uniquely defined. This method defines eight scales designated 000 to 111 in the binary data register under discussion.

Defining new subtrahends implements this method of scale definition in the sensor interface algorithm. Since, events output = total count - subtrahend, we add 512 counts to the output for scale 1. Then events output + 512 = total count - subtrahend + 512 or events output + 512 = total count - [subtrahend - 512] = total count - new subtrahend where the "new subtrahend" is 512 counts less than the original subtrahend. Likewise, by removing multiples of 512 from the original subtrahends defined in Table 2, new subtrahends are defined which also act as scale identifiers (see Table 5). The resolution per scale remains as listed in Table 3.

Table 5. Output Data Summary

Scale	Altitude		Preliminary Subtrahend	New Subtrahend	Counts
unitless	km	k ft	unitless		
0	0.30	~1	3100	3100	19
	0.00	0			36
	1.52	5			121
	7.62	25			401
	9.14	30			457
1	9.14	30	7000	6488	627
	10.7	35			723
	12.2	40			806
	13.7	45			873
	15.2	50			928
2	15.2	50	14750	13726	1107
	16.8	55			1196
	18.3	60			1268
	19.8	65			1326
3	19.8	65	30000	28464	1640
	21.3	70			1732
	22.9	75			1805
	24.4	80			1864
4	24.4	80	60500	58452	2204
	25.9	85			2296
	27.4	90			2369
	29.0	95			2425
5	29.0	95	121600	119040	2715
	30.5	100			2802
	32.0	105			2873
	33.5	110			2929
6	33.5	110	243800	240728	3211
	35.1	115			3295
	36.6	120			3365
	38.1	125			3421
7	38.1	125	488100	484516	3782
	39.6	130			3872
	41.1	135			3946
	42.7	140			4003
	44.2	145			4052

Note that Tables 3 and 5 were begun with an altitude below sea level to insure that the normal daily variation in barometric pressure at sea level locations, would not underflow the data register and produce confusing results. The output data summarized in Table 5 is graphed in Figure 3.

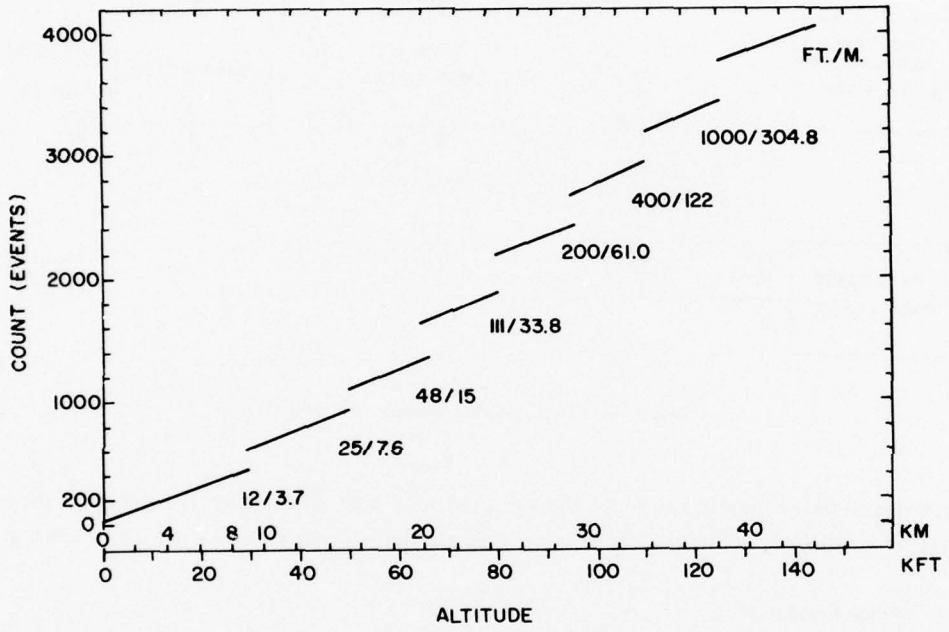

Figure 3. Count vs Altitude

4. FUNCTIONAL ANALYSIS

4.1 General

With the description of the algorithm behind us, it is time to consider each of the functional blocks of Figure 2. At this point they will not be analyzed to the point of what device implements what function, but rather to the level of logic functions needed to accomplish each task. The device number and pin utilization will be considered in a later section. Positive logic will be used throughout.

Figure 4 is based on Figure 2 and considers power supplies, and the number of wires to get information from block to block. Power supply wires and the

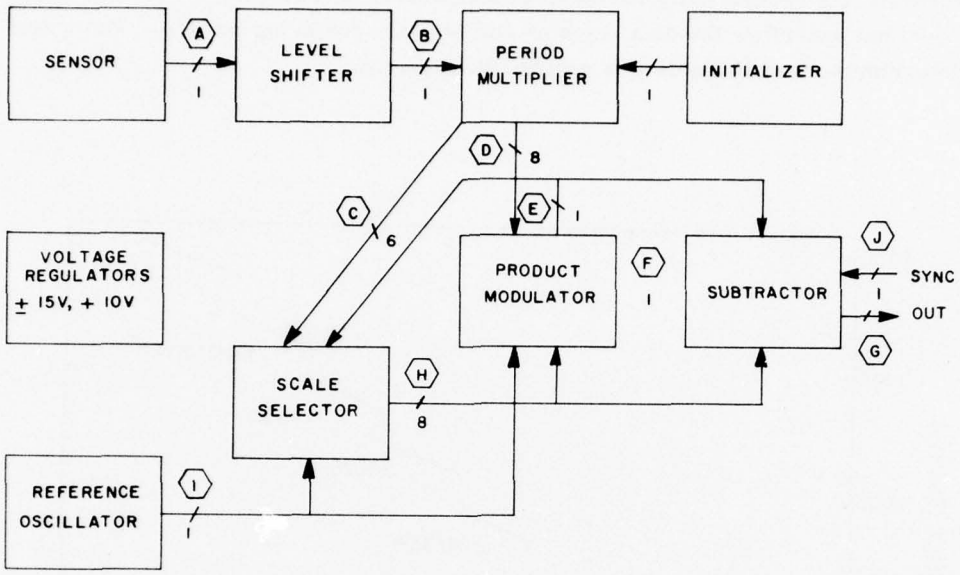

Figure 4. Equipment Block Diagram

initializer pulse routing are not shown; consider that when they are needed, they will be available. The capital letters are placed at break points for referencing.

4.2 Voltage Regulators

All power will be supplied from a 12 Vdc battery with negative system ground. Sensor power, ±15 Vdc, will be obtained from a commercially available dc/dc converter. Logic power, +10 Vdc, will be supplied by a regulator documented in the next section.

4.3 Initializer

A logic "1" will be generated by an RC differentiator when power is applied and will be used where necessary to insure that the state of certain devices is known when the measuring process begins.

4.4 Reference Oscillator

A one megahertz, crystal controlled, capacitor trimmable oscillator with 50-50 duty cycle for CMOS logic is commercially available. Utilized in a voltage

regulated, constant load regime with small temperature change ($20^{o}C \pm 10^{o}C$), a maximum error of ±1/2 PPM is possible.

4.5 Sensor

Several characteristics of the sensor have been covered in the preceding sections and more information has been referenced. The most significant point now is that the output swings from 0 to 5 Vdc in a 50-50 duty cycle square wave. This voltage level must be up-shifted to the 10 Vdc level at which the CMOS logic operates.

4.6 Level Shifter

A simple transistor inverter will perform the level shifting operation. It will be followed by an inverting buffer to insure sharp transitions (see Figure 5).

4.7 Period Multiplier

This function is performed by a synchronous binary counter (see Figure 6). Note that twelve stages of period multiplication are shown, even though Table 3 indicates that eleven is the highest power used. The reason for this is shown in Figure 6(b). Carrying the multiplication one step further than necessary results in a series of logic "1" (or "0") pulses which has the duration of the period of the required state. The utility of this approach will be shown in a few paragraphs. Note that the multiplier is initialized when power is applied and then tracks the period of the sensor. The output of any Q is

$$Q_n = p \times 2^n \quad ,$$

where p is the period of the sensor; the units of Q are the same as p.

4.8 Product Modulator

This section includes a commutator and multiplier. As seen in Figure 7, the multiplier is a simple AND gate which by definition performs the multiplication function as indicated by its symbols: dot (.) and cross (x). Another way of looking at the process stems from an older name of the AND circuit: a coincidence circuit.[*3] When both inputs are logic 1's, a logic 1 appears at the output; or, the Q_n input modulates the reference oscillator. Hence, the name describes the function: product modulator.

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*See reference 3, page 317.

3. Millman, J., and Taub, H. (1965) Pulse, Digital, and Switching Waveforms, McGraw-Hill Book Co., New York.

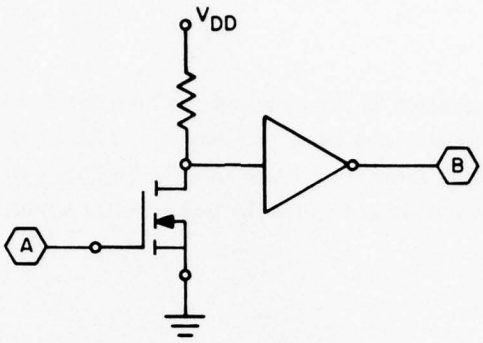


Figure 5. Level Shifter (Basic)

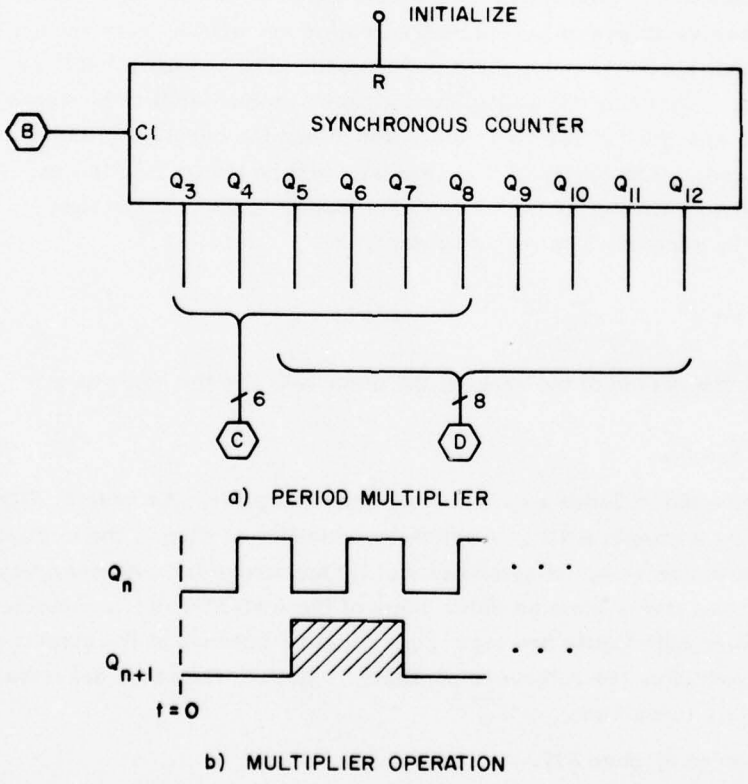
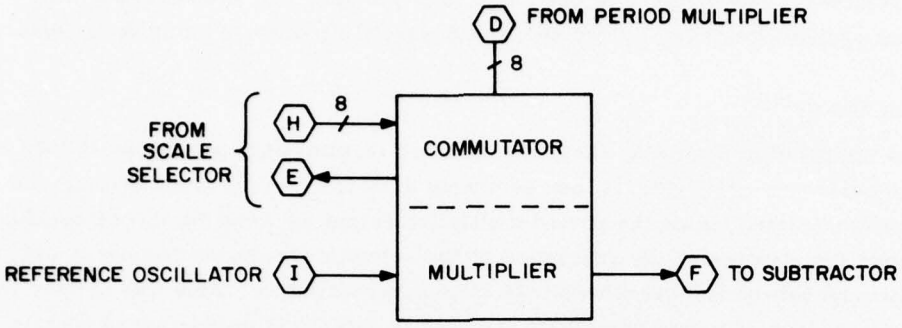
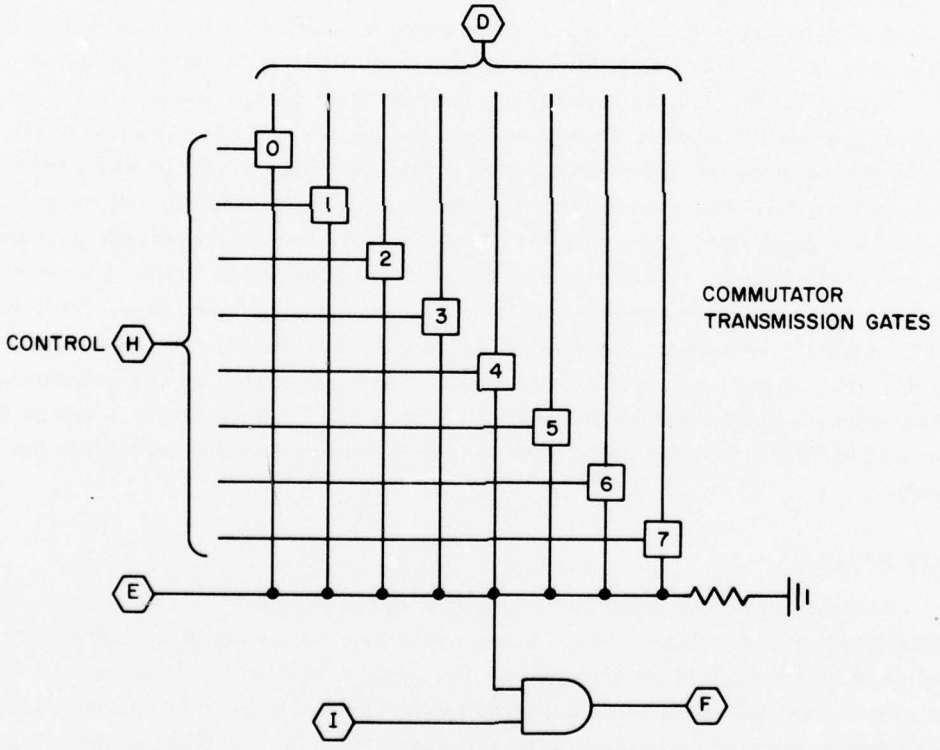


Figure 6. Period Multiplier (Basic)



a) EXPANDED BLOCK DIAGRAM



b) LOGIC DIAGRAM

Figure 7. Product Modulator (Basic)

Tri-state transmission gates form the commutator which is controlled by the scale selector. The output E is used as a flag to insure that the scale selector does not change commutator segments while a multiplication is being performed.

4.9 Scale Selector

As indicated in Figure 2, the scale selector monitors the period multiplier and the reference oscillator; it then performs a period measurement through the product multiplier. Since the period multiplier output (Q_8) and reference oscillator output are constants, the resolution of the selector tracks the frequency output from the sensor and decreases with increasing altitudes. This was defined in Table 4. A read only memory, ROM, is used to detect the proper set of outputs which defines the number of events in Table 3. There is one ROM output for each of the seven switching points. An R/S latch is used to detect a logic 1 at the ROM outputs (see Figure 8). A bank of gates allows only the most significant (highest magnification) scale detected to be presented to the clocked latches which form the output of the scale selector. After a scale has been selected and clocked into the D latches, the counter and R/S latches are reset for the next selection process.

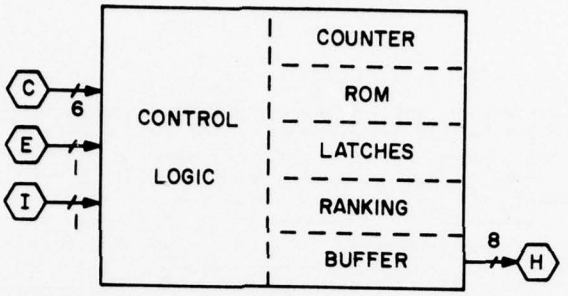
Figure 8 shows that six outputs are derived from the Q outputs brought in to the scale selector as group C; Figure 9 shows where they fall in relation to the period being measured (shaded Q_8 pulse). Note that the working (WRK) period is not used directly, but defines the time during which the jam (JAM) and reset (RST) pulses are generated. Remember that the Q outputs are wholly dependent on the period of the sensor, thereby locking the JAM and RST pulses to the same standard. Therefore, the scale is being selected continuously, based on the frequency of the sensor; meanwhile, the sensor period is being measured for the output (point G) by another part of the instrument. The scale cannot be changed during a measurement cycle, defined by E (see Figures 6 and 7), because the signal at E is used to inhibit the JAM pulse when the product multiplier and subtractor are busy.

4.10 Subtractor*

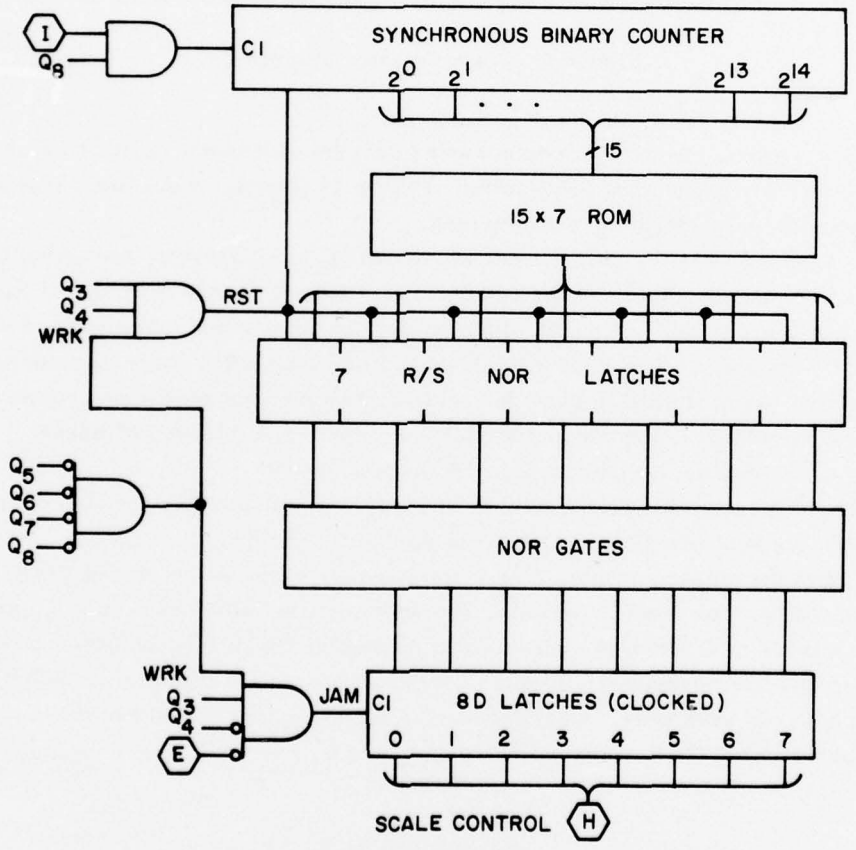
The subtractor and multiplier work together to produce a pulse burst as previously described. Figure 10 has an expanded block diagram of the subtractor followed by a simple block schematic. Besides subtracting the requisite number of events from the pulse burst produced by the product modulator, the subtractor also synchronizes the output with the encoder. Therefore, the latter part of this subsection is heavily slanted toward presenting the information to that encoder.

---

*See Appendix D.



a) EXPANDED BLOCK DIAGRAM



b) LOGIC DIAGRAM

Figure 8. Scale Selector (Basic)

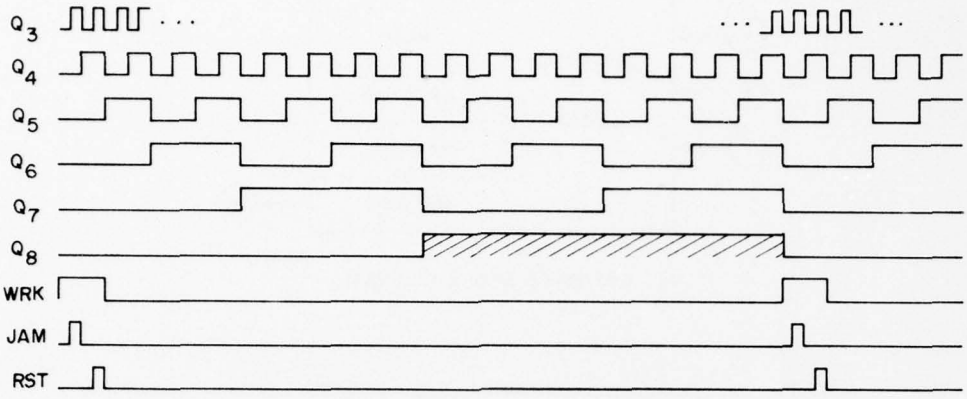
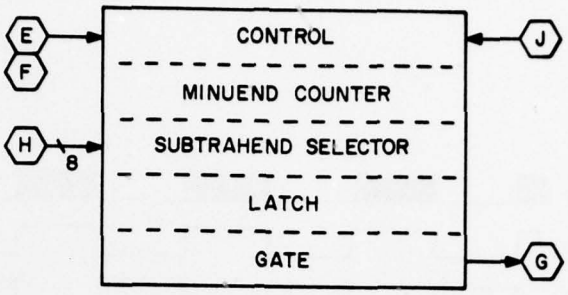


Figure 9. Scale Selector Timing

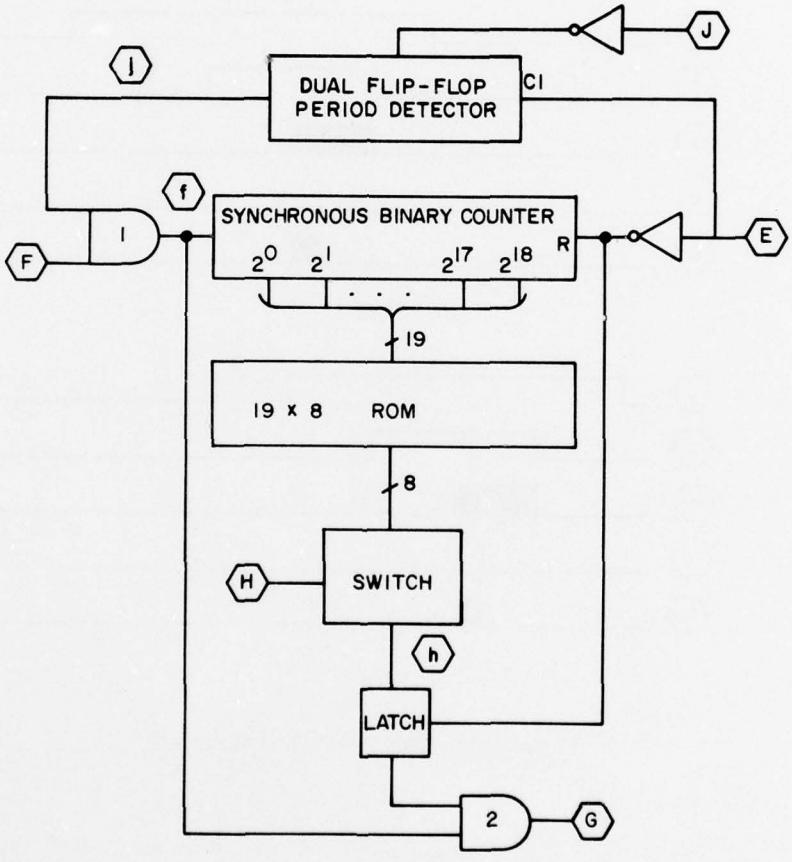
In another scheme the informative number of events could very easily be stored in the counters for subsequent processing. Figure 11 presents waveforms that aid understanding the subtractor's functioning.

As explained earlier, when a certain output Q_n is of interest, the output Q_{n+1} is used to facilitate mixing by the AND circuit. Figure 11 has been scaled for a Q_n period of about half a second, which is slightly larger than that produced in scale "7" operation. The J input (logic 1) is 2 sec long. The three waveforms in part (a) are, as explained in previous section, keyed to the sensor and continuing. The first waveform is the product modulator output: the minuend M where $M = Q_{n+1} \cdot C$ and the coefficient C is 10^6 events/second.

The subtractor is controlled by the J input from the encoder through the period-detecting dual flip-flop circuit. When gate 1 is enabled, the counter presents to the ROM the elapsed events. The scale selector chooses the proper ROM subtrahend. When that number appears, (waveform h) the latch opens gate 2, producing waveform G which is a pulse burst containing the difference between the minuend and the subtrahend. Figure 11(b) and (c) show the effect of changing the timing of J. In each case, the difference is the same, but the placement of the pulse burst within the encoder aperture (j) changes.



a) EXPANDED BLOCK DIAGRAM



b) LOGIC DIAGRAM

Figure 10. Subtractor (Basic)

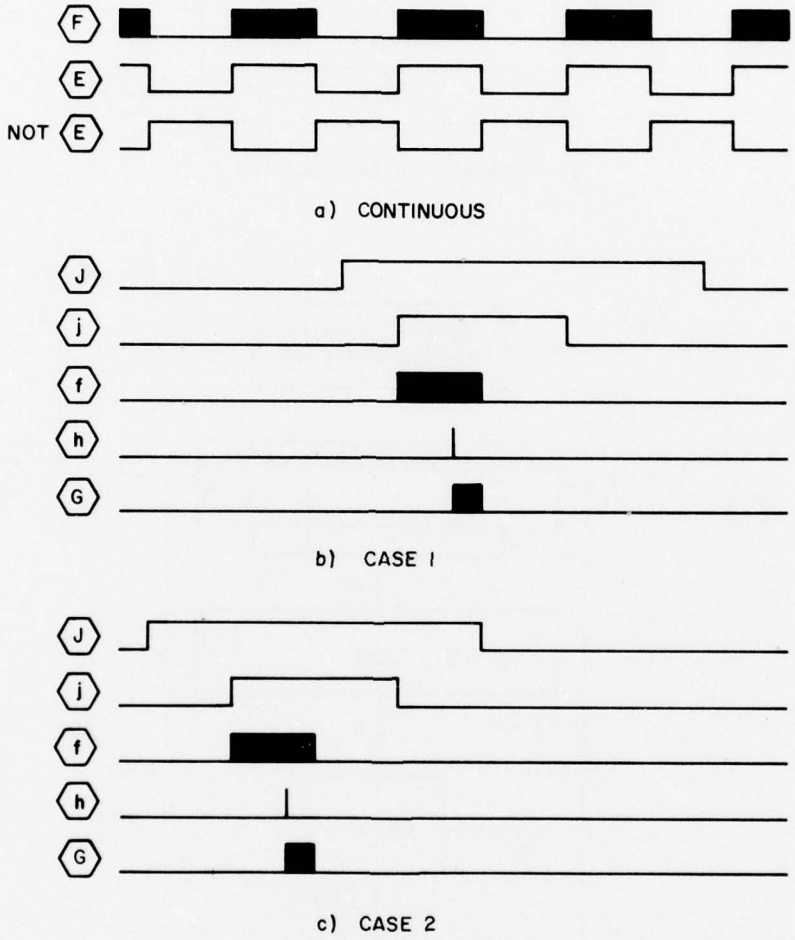


Figure 11. Subtractor Waveforms

5. IMPLEMENTATION

5.1 General

This section explains a collection of schematics suitable for fabrication; that is, it gets down to the package level. The schematics are in Appendix A. Most of the circuits are straight forward; and, with the explanation of section 4, should be understandable. Therefore, unless a point needs further clarification, it will not be discussed.

5.2 Initialization

The schematic block diagram shows that the reset pulse generated by the initializer goes only to the period multiplier. Why? How do the counters in the scale selector and subtractor get initialized? The reset pulse (RST) generated by the scale selector control section initializes them.

The initializer holds the period multiplier reset for about 12 msec. Subsequently, the counter begins to advance; the WRK output is a logic 1 because sufficient events have not occurred. In 2.4 msec, an 0.8 msec RST pulse initializes the scale selector and subtractor. These times are based on a 0.20 msec sensor period. RST pulses occur every 51 msec, so the scale data will be fresh by time the encoder completes its initialization and framing pulse generation (2 sec). See Figure 12. Note that these times are based on a specific sensor output period which was assumed to have a logic 1 to $\emptyset$ transition immediately before the initializing pulse ended.

5.3 Capacitors

Every capacitor in this device is for power supply filtering or radio frequency energy (RF) bypassing. The latter are included because of the severe RF environment in which the altimeter must function.

5.4 Logic Substitutions

In section 4, it was convenient to define logic functions with AND gates and NOT gates. However, during implementation this is usually not optimum. For example, the output at point F in Figure A4 is inverted with respect to an AND output; but, since there is no attempt to control the phase relationship of Y1 and the sensor, it doesn't matter. In other cases, the need for an AND gate was imperative so it was provided as in Figure A5. In this same figure, note that the NOR gate is the implementation of the AND gate with inverted inputs in Figure 8b. Such conversions are in accordance with DeMorgan's laws.*

*See reference 3, page 328-330.

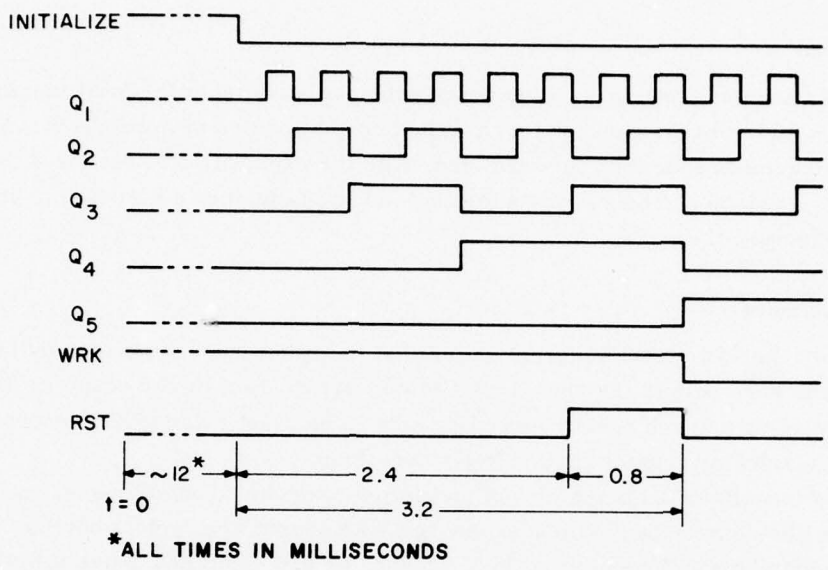


Figure 12. Interface Start-up Waveforms

5.5 ROM Programming

There are two ROM's in this instrument; the scale selector ROM will be discussed first. This ROM, which detects when the count for each of the scale "break points" is reached, is programmed for the binary count, as noted in Table 6(a). The ROM passes the information from the counter to the latches virtually instantaneously; the latch reacts in nsec.

This highlights a potential problem in the Subtractor ROM function. If that ROM were set to detect the subtrahends listed in Table 4, the event at which the subtrahend was detected would be counted as part of the remainder. This is precluded by setting the ROM for the number equal to the subtrahend plus 1. These values and the resulting codes are listed in Table 7(a). The second part of each Table (6 and 7) lists the pin number links to be removed from each new matrix to produce the defined ROM. These same links are redefined by row and column in Table 8.

Table 6. Scale Selector ROM Codes

(a) binary word generation

Break Points		Period	Multiplier	Count		
k ft	km	μ sec	Hertz	$events_{10}$	$events_{8}$	$events_{2}$
30	9.14	222.374	$2^{7} \times 10^{6}$	28463	67457	110 111 100 101 111
50	15.2	231.770		29666	71742	111 001 111 100 010
65	19.8	235.188		30104	72630	111 010 110 011 000
80	24.4	236.938		30328	73170	111 011 001 111 000
95	29.0	237.804		30438	73346	111 011 011 100 110
110	33.5	238.222		30492	73434	111 011 100 011 100
125	38.1	238.427		30518	73466	111 011 100 110 110

(b) paths to remove (pin numbers)

Column A12-A14	Rows		
	A12	A13	A14
1	6	3, 4	4
7	2, 4, 5, 6	none	2, 3
14	2, 3, 4	2, 3, 6	3
8	2, 3, 4	4, 5	3
13	2, 5, 6	5	3
9	2, 3	2, 3, 4	3
12	2, 5	3, 4	3

Table 7. Subtractor ROM Codes

(a) binary word generation

Scale	Subtrahend* +1		
	base 10	base 8	base 2
0	3101	6035	000 000 000 110 000 011 101
1	6489	14531	000 000 001 100 101 011 001
2	13727	32637	000 000 011 010 110 011 111
3	28465	67461	000 000 110 111 100 110 001
4	58453	162125	000 001 110 010 001 010 101
5	119041	350401	000 011 101 000 100 000 001
6	240729	726131	000 111 010 110 001 011 001
7	484517	1662245	001 110 110 010 010 100 101

(b) paths to remove (pin numbers)

Column A26-A29	Rows			
	A26	A27	A28	A29
1	3	2, 3, 4, 5, 6	4, 5, 6	2, 3, 4, 5
7	3, 4	2, 4, 6	2, 5, 6	2, 3, 4, 5
14	none	2, 3, 6	3, 6	2, 3, 4, 5
8	3, 4, 5	3, 4	4	2, 3, 4, 5
13	3, 5	2, 4, 5, 6	3, 4	3, 4, 5
9	3, 4, 5, 6	2, 3, 4, 6	2, 3, 5	4, 5
12	3, 4	2, 4, 5, 6	4, 6	5
10	3, 5, 6	3, 5, 6	3, 4	2

*From Table 4.

Table 8. Scale Selector and Subtractor ROM Paths Removed by Row and Column

(a)

Column A26-A29	Rows			
	A26	A27	A28	A29
1	2	1, 2, 3, 4, 5	3, 4, 5	1, 2, 3, 4
2	2, 3	1, 3, 5	1, 4, 5	1, 2, 3, 4
3	none	1, 2, 5	2, 5	1, 2, 3, 4
4	2, 3, 4	2, 3	3	1, 2, 3, 4
5	2, 4	1, 3, 4, 5	2, 3	2, 3, 4
6	2, 3, 4, 5	1, 2, 3, 5	1, 2, 4	3, 4
7	2, 3	1, 3, 4, 5	3, 5	4
8	2, 4, 5	2, 4, 5	2, 3	1

(b)

Column A12-A14	Rows		
	A12	A13	A14
1	5	2, 3	3
2	1, 3, 4, 5	none	1, 2
3	1, 2, 3	1, 2, 5	2
4	1, 2, 3	3, 4	2
5	1, 4, 5	4	2
6	1, 2	1, 2, 3	2
7	1, 4	2, 3	2

5.6 Fabrication

The transducer and the circuits documented in Appendix A are packaged in a 16.5 cm × 14.0 cm × 10.2 cm (6.5 in × 5.5 in × 4.0 in) container. The circuts are on three circuit cards whose layouts are in Appendix B; the instrument is shown in Figure 13.

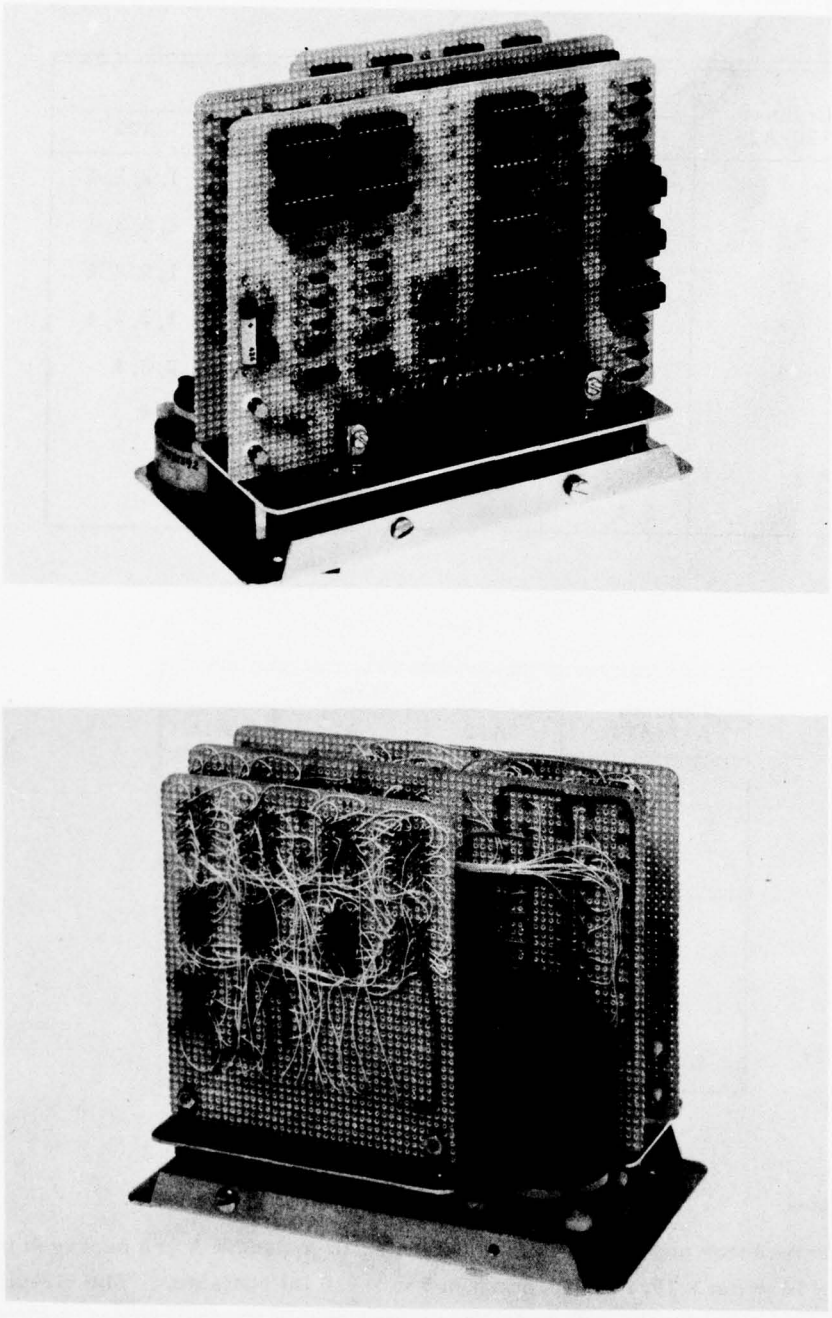


Figure 13. Interface With Sensor

6. DATA RETRIEVAL

As described earlier, the data word has twelve bits in four 3-bit groups. The existing data acquisition system, into which the sensor and its interface gain access through the encoder, prints data words in a letter code defined by Table 9; each data word is printed as a four letter code. The object of the data retrieval system is to relate every possible code word to the U. S. Standard Atmosphere; a computer program accomplished this task.

Table 9. Codes

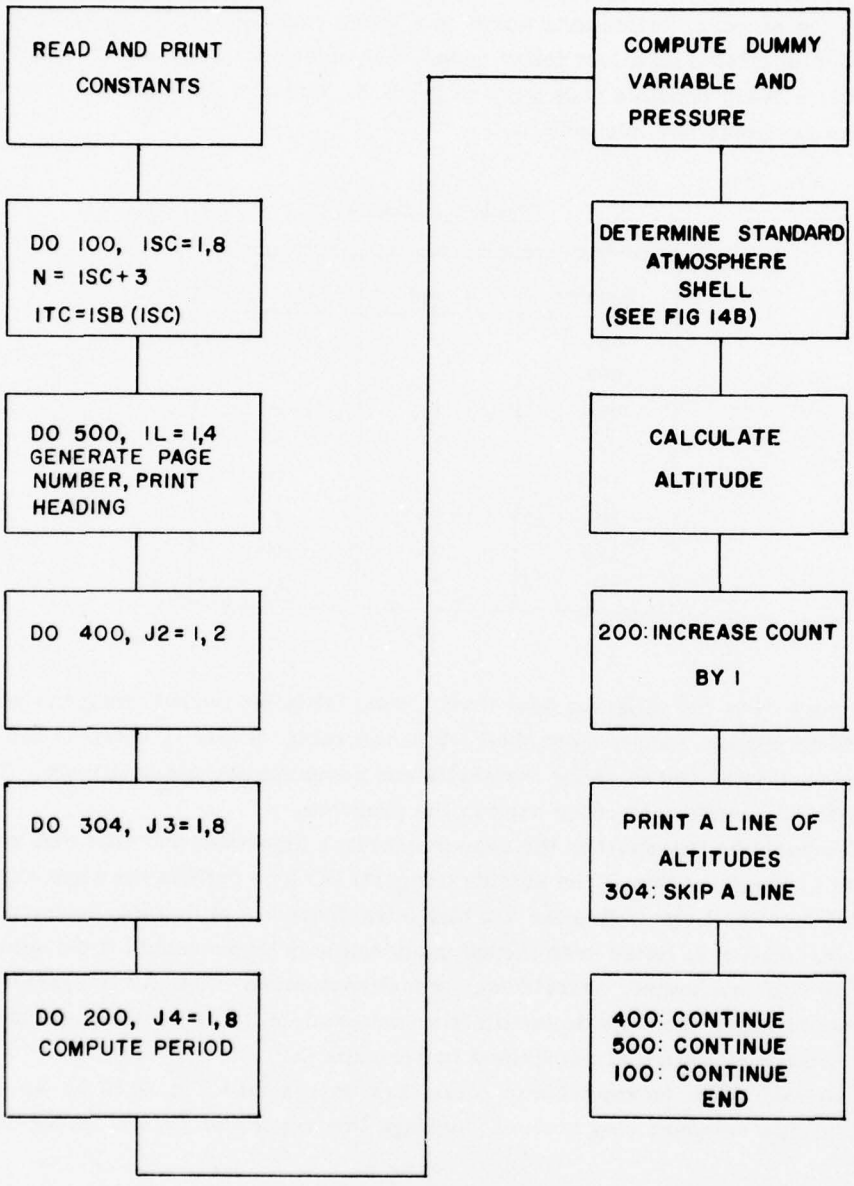
Binary	Octal	Letter
000	0	S
001	1	U
010	2	R
011	3	W
100	4	D
101	5	K
110	6	G
111	7	O

Figure 14 is the program flow chart. Part (a) is the overall program while part (b) details the atmospheric shell* determination. Table 10 contains the reference constants used to define the shells and computes the exact altitude. Table 11 defines the mnemonic codes used in the program.

Compare the flowchart to the sensor interface algorithm and note that it is the inverse of the algorithm. The outside (largest) DO loop defines the eight scales; the next four DO loops define the 512 bits in each scale. In this way every possible code combination is listed even though many can only be generated if the scale selector is disconnected, overridden, or malfunctioning. The 512 bits/scale are generated by four DO loops to facilitate a neat printout. The source code and subsequent machine listing are contained in Appendix C.

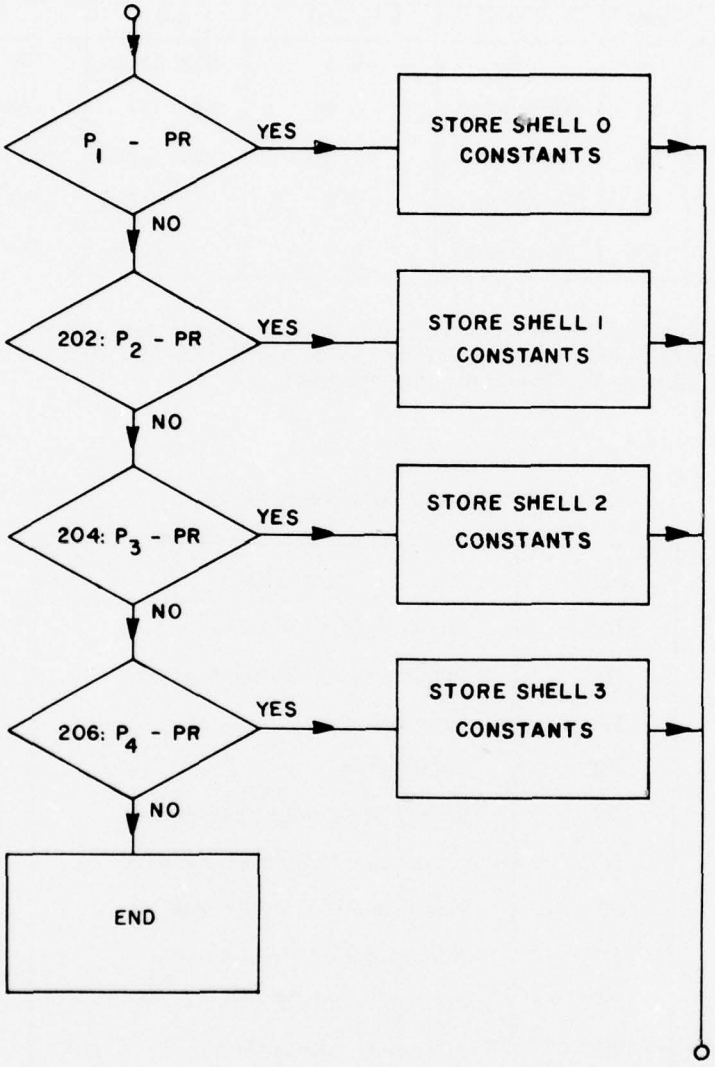
The body of the lookup table or dictionary is less than 8 in. × 10 in. so it can be cut to fit a standard ring binder. Average line resolution data is on the far right.

*Based on U. S. Standard Atmosphere, reference 2.



(a)

Figure 14a. Computer Program Flow Chart



(b)

Figure 14b. Standard Atmosphere Shell Determination

Table 10. Atmospheric Constants

Subscript	Geopotential Height		Temperature Gradient	Pressure	Temperature
b	H_b		$L_{m,b}$	P_b	$T_{m,b}$
unitless	km'	k ft	K/km'	mb	K
0	0	0	-6.5	1013.2500	288.15000
1	11	36.089239	0.0*	226.321	216.6500
2	20	65.616798	+1.0	54.7489	216.6500
3	32	104.98688	+2.8	8.68014	228.6500
4	47	154.19948	0.0	1.1090	270.6500

*In the computer program, 0.0001 in place of 0.0 yields data identical to that tabulated in reference 2 and precludes using a different equation. The author thanks Mr. James F. Dwyer for this suggestion.

Table 11. Mnemonic Codes

Code	Definition
IBK	block, 8 lines of code
IL	leaf or page, four per scale
IPG	page counter
ISB	subtrahend
ISC	scale, MSB, eight per sensor
ITC	total count, same as minuend
J2	block counter, 2 per page
J3	line counter, 8 per block
J4	column counter, LSB, 8 per line
PR	pressure, atmospheric

7. TESTING

7.1 Functional Tests

Prior to checking how well (or poorly) the device performed, it was necessary to see if it worked at all. Table 12 is the general procedure used to check the instrument. The first step is critical; there is no margin for error.

Table 12. Check Procedure

Step	Function
1	With power disconnected assure that the sensor mating connector is disconnected. Apply power, measure voltage, and check polarity at the sensor mating connector.
2	Check initializer pulse at period multiplier.
3	Connect sensor; check output with scope and counter.
4	Check level shifter.
5	Check period multiplier.
6	Trim reference oscillator to ±0.1 Hertz.
7	Check scale selector. See Figure 9.
8	Check product modulator. See Figure 11.
9	Check subtractor. See Figure 11.

7.2 Interface Tests

Tests described in this section were accomplished by replacing the sensor output with a function generator monitored by a frequency counter. Application of a very gentle touch on the generator vernier control and a good deal of patience, enabled the periods to be set to five place accuracy.

The initial data were gathered based on the periods in Table 2. The results were repeatable within a bit, but above 12.2 km (40 k ft) the error grew to -2 bits, above 33.5 km (110 k ft) to -10 bits, and above 36.6 km (120 k ft) to -20 bits. Analyzing the test setup led to two conclusions: (1) at the highest altitudes the error was due to the accuracy of the input period which, in turn, was a function of Table 2 and the function generator; and (2) in the middle range 12.2 km to 18.3 km (40 k ft to 60 k ft), the error was due to the linear interpolation error when Table 2

was calculated from tables in the U. S. Standard Atmosphere (reference 2) and the sensor instruction manual (reference 1).

The function generator was the easier of the two problems to solve. It was replaced with a more stable unit which could hold better than six places accurately. Producing more accurate periods for test altitudes took a good deal of time.

Six place accuracy was the minimum acceptable. The U. S. Standard Atmosphere is tabulated to five places; the sensor manual has data to six places. However, since neither function is linear, interpolation would introduce an error due to the curvature of the function. Maximum accuracy could be obtained only by calculating the exact period. Calculating atmospheric pressure at some altitude is straightforward; calculating sensor period from that pressure is more involved.

The sensor function is defined in section 2. To proceed from the dependent variable (pressure) to the independent variable (period), a point search by interval halving algorithm was devised. This algorithm produced a period which corresponded to a pressure accurate to within one-tenth the absolute sensor error. The algorithm flowchart is in Appendix E.

The standard atmosphere formula and the sensor formula with the point search algorithm were coded into a Hewlett-Packard 9810 calculator, and a new period vs altitude table was produced. Comparing the periods in Table 2 and Table 13, highlights the increased accuracy of the latter data. Table 13 holds the data generated when the interface was then retested using the more accurate periods. If the empirical data are compared to the computer printout in Appendix C, it will be noted that every point is within less than one bit of the control altitude. This test effectively closes the loop on the interface design.

7.3 Altimeter Chamber Tests

The final test includes the sensor and interface in an "altitude" check via vacuum chamber. This test was accomplished using three different instruments to monitor the chamber pressure altitude. A Wallace and Tiernan (W & T) Model FA129 gauge was used from 1.52 to 12.2 km (5 to 40 k ft); a MKS baratron pressure meter type 77, from 12.2 to 25.9 km (40 to 85 k ft); and a W & T Model FA160 gauge, from 25.9 to 44.2 km (85 to 145 k ft). In Table 14, Altimeter Test Data, the points where the monitor instrument changed are listed twice, one datum point on each instrument. The reported altitude is the mean of data gathered by three technicians. In all cases, the data are within the absolute error of the altimeter/chamber system.

Conspicuous by its absence is a datum point at 0 km. Recall Table 2, the sensor accuracy is 1.5 m (5 ft) at that altitude. Also, the altimeter resolution is 18 m (58 ft) at that altitude. Therefore, at sea level the altimeter readily responds

to changes in barometric pressure. An ambient check of its accuracy was accomplished using a quartz manometer. In every case, the closure was less than the units resolution.

Table 13. Interface Test Data

Altitude k ft	Period μ sec	Empirical data k ft
0	196.0438	0.02
5	201.3297	4.98
10	206.3008	10.01
15	210.9188	14.95
20	215.1523	19.97
25	218.9820	24.94
30	222.3988	29.96
35	225.4039	35.00
40	227.9750	39.99
45	230.0862	45.02
50	231.8056	49.97
55	233.1973	54.96
60	234.3181	59.97
65	235.2167	64.96
70	235.9329	69.98
75	236.5000	75.00
80	236.9489	79.96
85	237.3039	85.01
90	237.5847	90.02
95	237.8069	94.99
100	237.9829	100.05
105	238.1223	105.03
100	238.2322	110.01
115	238.3187	115.04
120	238.3871	120.05
125	238.4412	125.02
130	238.4843	130.00
135	238.5188	135.04
140	238.5464	140.00
145	238.5686	145.06

Table 14. Altimeter Chamber Test Data

Control Altitude		Reported Altitude	Standard Deviation
km	k ft	k ft	k ft
1.52	5	5.02	0.03
3.05	10	9.97	0.03
4.57	15	15.04	0.04
6.10	20	20.09	0.05
7.62	25	25.05	0.05
9.14	30	29.96	0.05
10.7	35	34.91	0.03
12.2	40	39.88	0.05
12.2	40	40.05	0.00
13.7	45	45.07	0.05
15.2	50	50.04	0.03
16.8	55	55.04	0.04
18.3	60	59.97	0.00
19.8	65	64.89	0.03
21.3	70	69.81	0.03
22.9	75	74.69	0.00
24.4	80	79.60	0.05
25.9	85	84.42	0.03
25.9	85	84.95	0.06
27.4	90	89.90	0.09
29.0	95	94.77	0.06
30.5	100	99.76	0.13
32.0	105	104.67	0.05
33.5	110	109.59	0.06
35.1	115	114.60	0.13
36.6	120	119.50	0.28
38.1	125	124.72	0.21
39.6	130	129.28	0.31
41.1	135	134.79	0.79
42.7	140	139.69	1.13
44.2	145	145.60	0.59

8. CONCLUSION

Tables 13 and 14 are the best conclusion this report could have; the instrument worked as designed. Figure 15 depicts the functioning of the altimeter and computer program plus the tests documented above. At present only one of these instruments has been fabricated, but the second will be schematically identical to the first. The firmware (ROM's) and software (altitude dictionary) will change in response to the coefficients of the sensor equations as set forth in the algorithm.

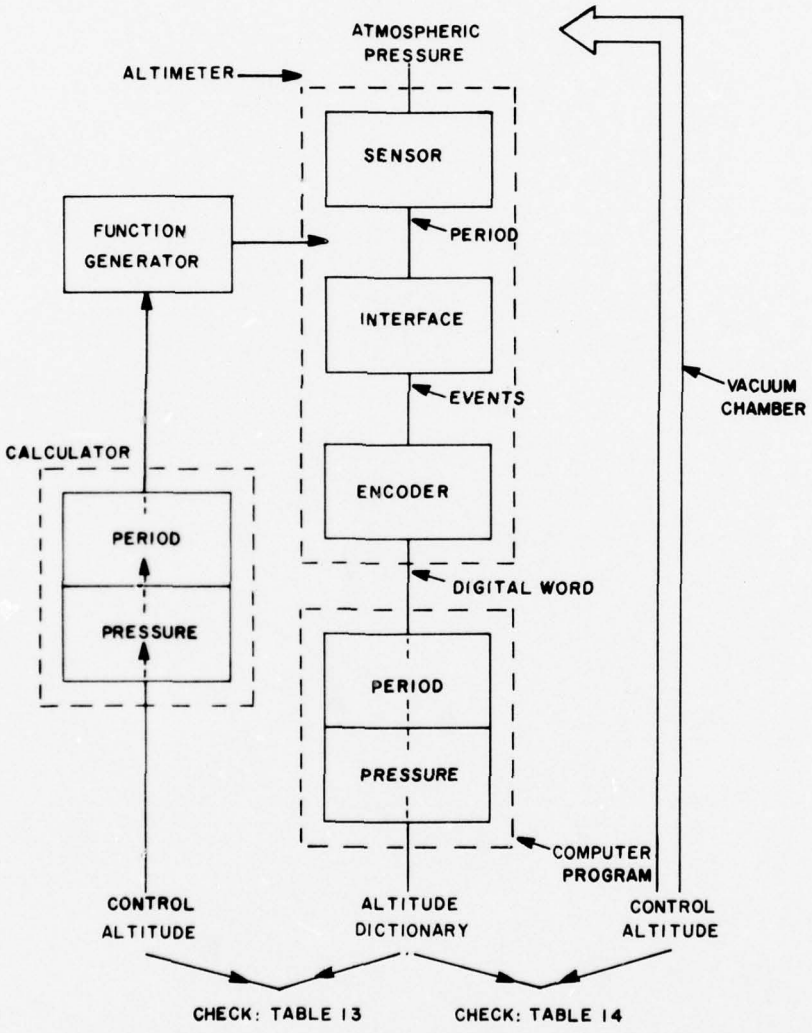


Figure 15. Altimeter System and Tests

Appendix A

As Built Schematics

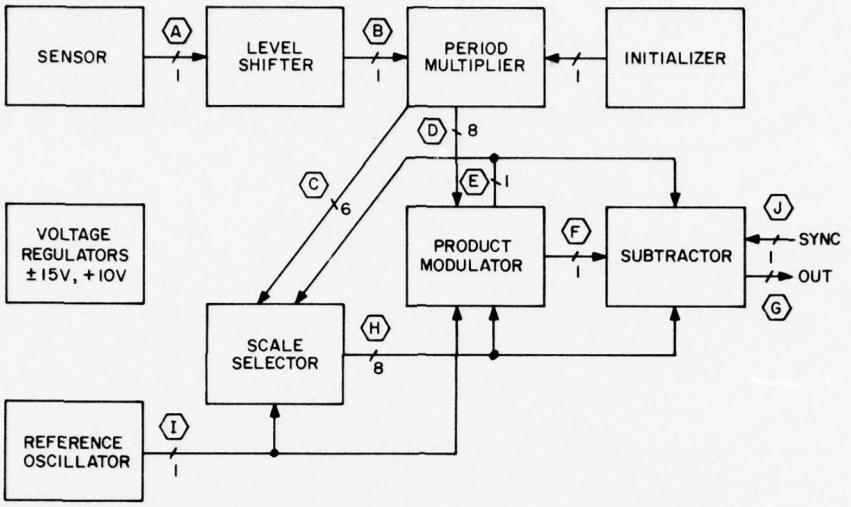


Figure A1. Altimeter Block Diagram

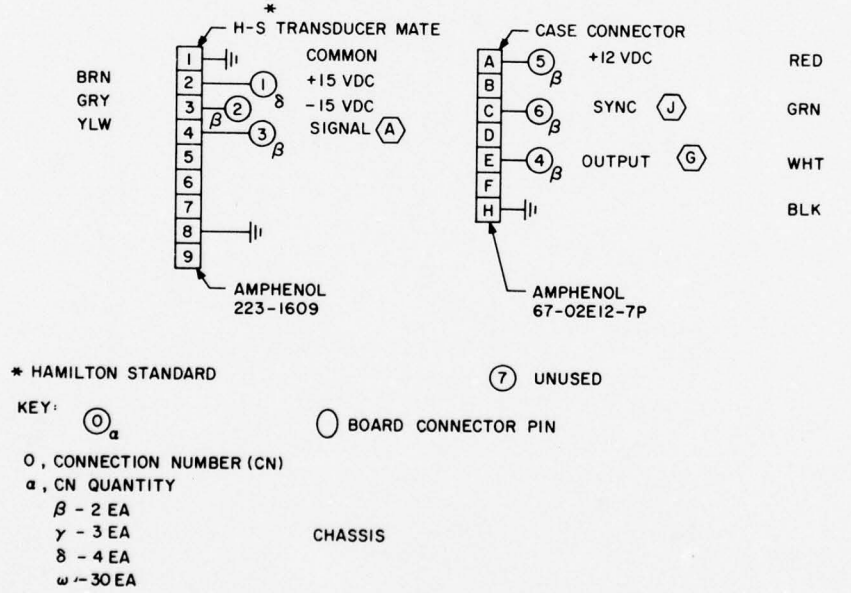
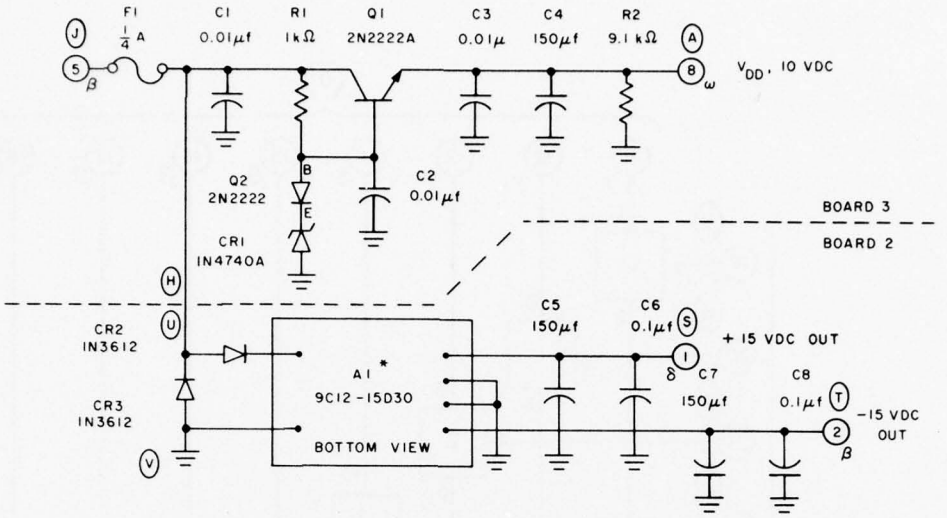


Figure A2. Sensor and Case Connectors



* SEMICONDUCTOR CIRCUITS, INC.

Figure A3. Voltage Regulators

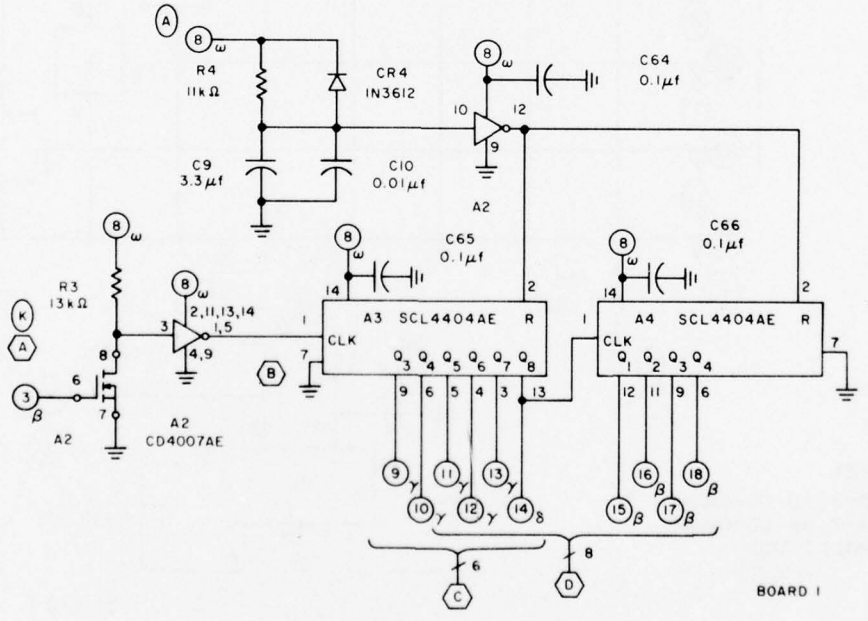


Figure A4. Level Shifter, Initializer, Period Multiplier

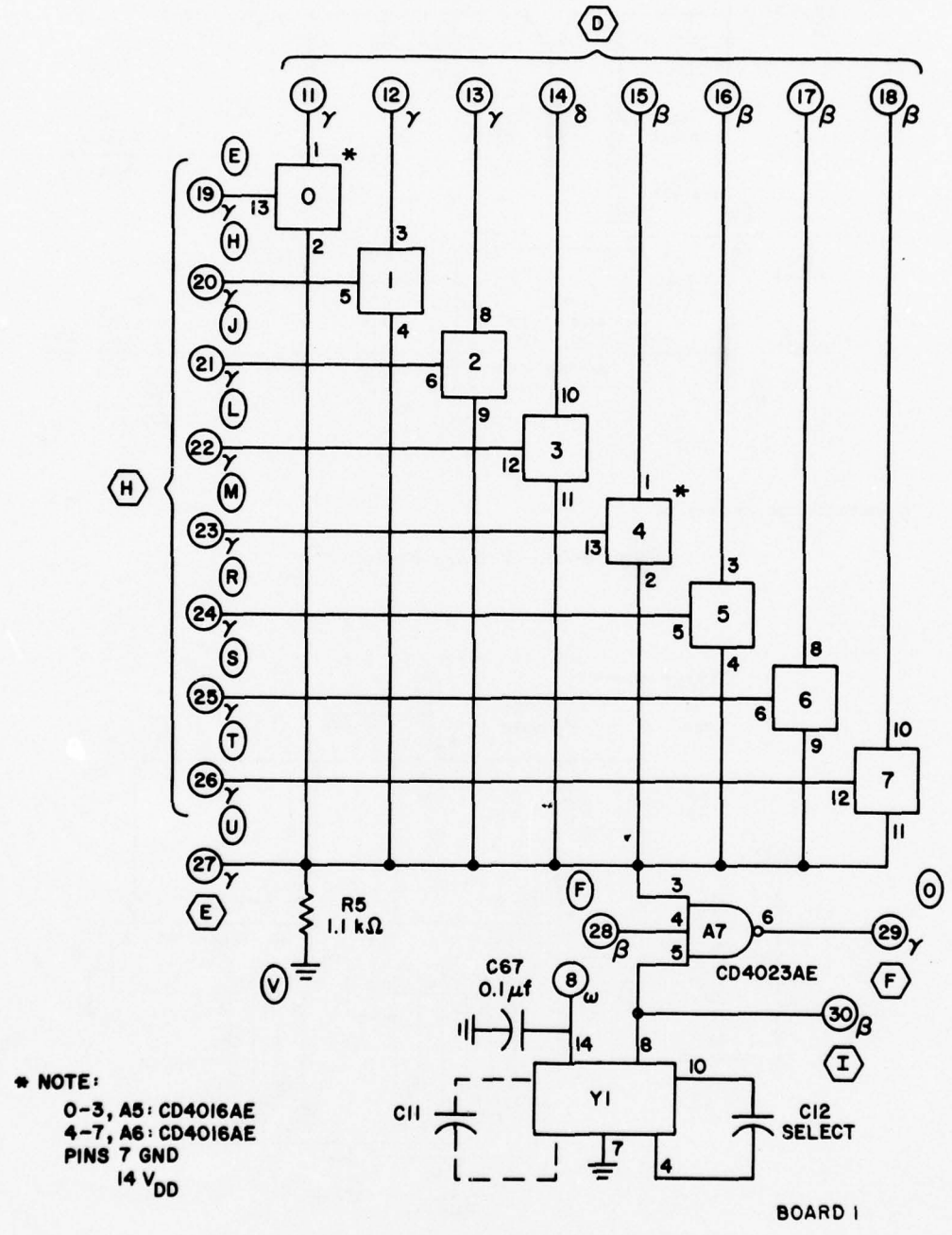


Figure A5. Product Modulator

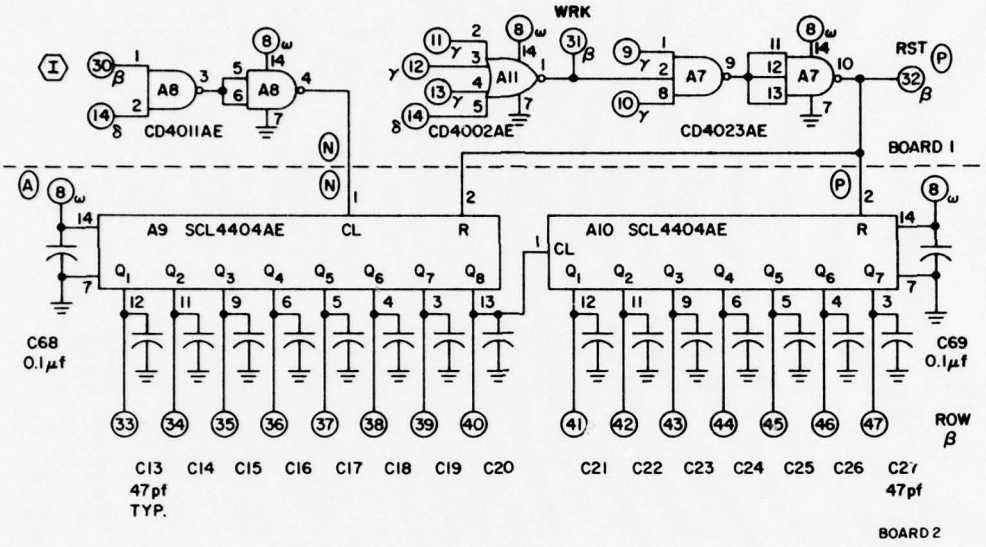


Figure A6a. Scale Selector Counter

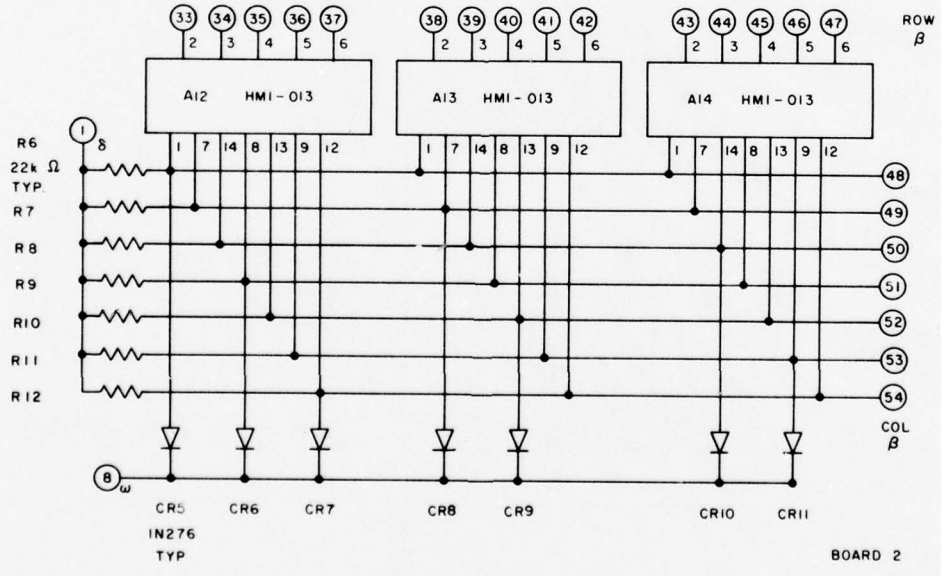


Figure A6b. Scale Selector ROM

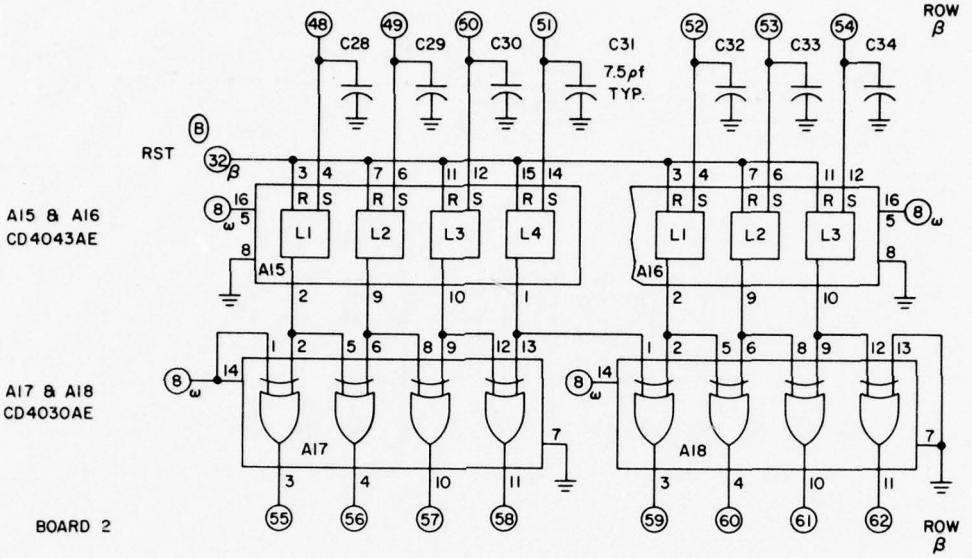


Figure A6c. Scale Selector Latches and Ranking Gates

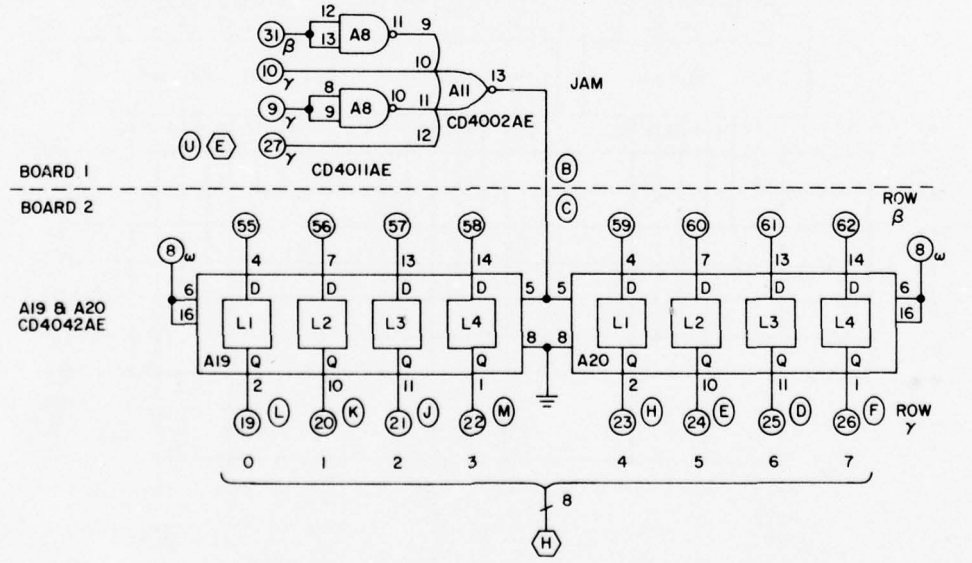


Figure A6d. Scale Selector Buffer Register

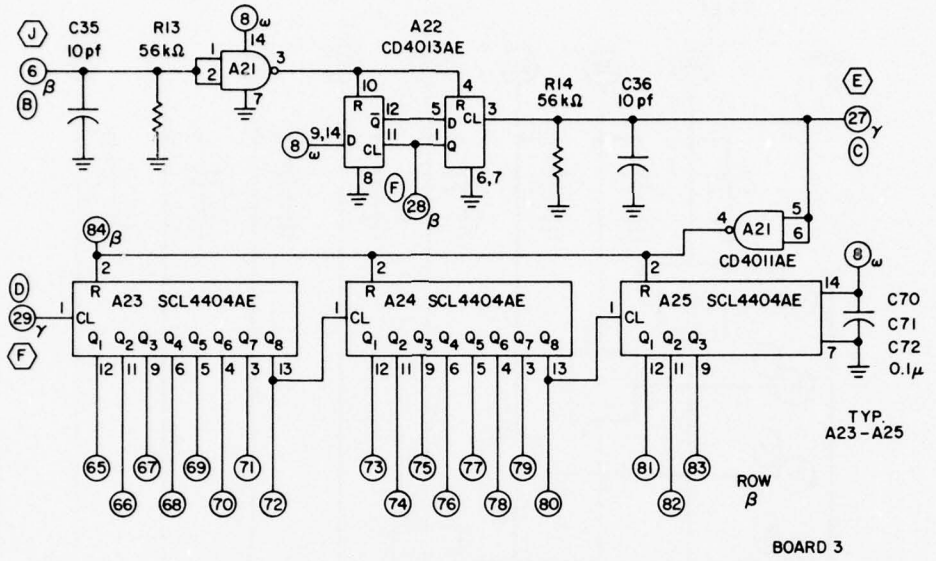


Figure A7a. Subtractor Control and Counter

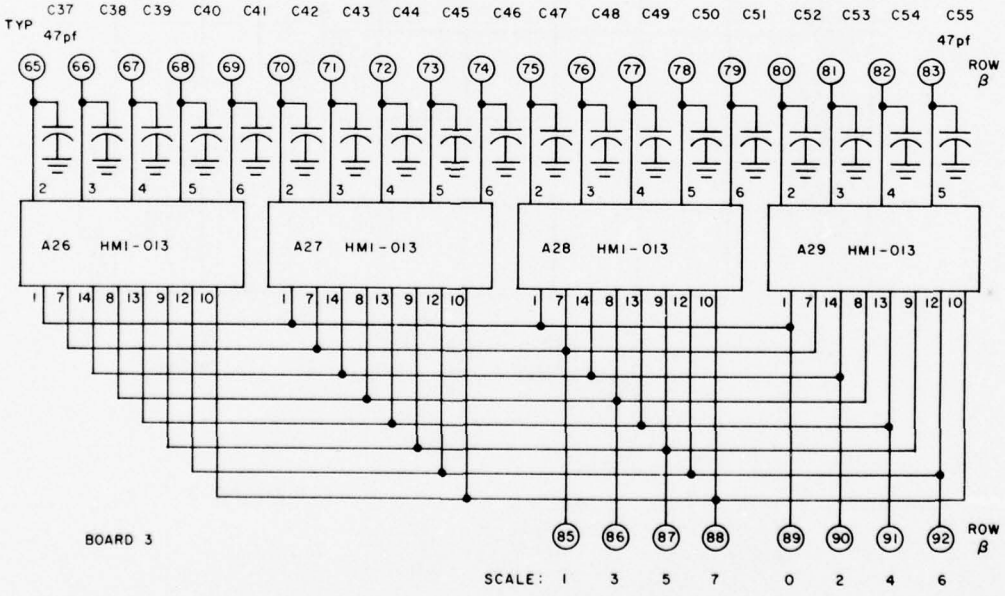


Figure A7b. Subtractor ROM

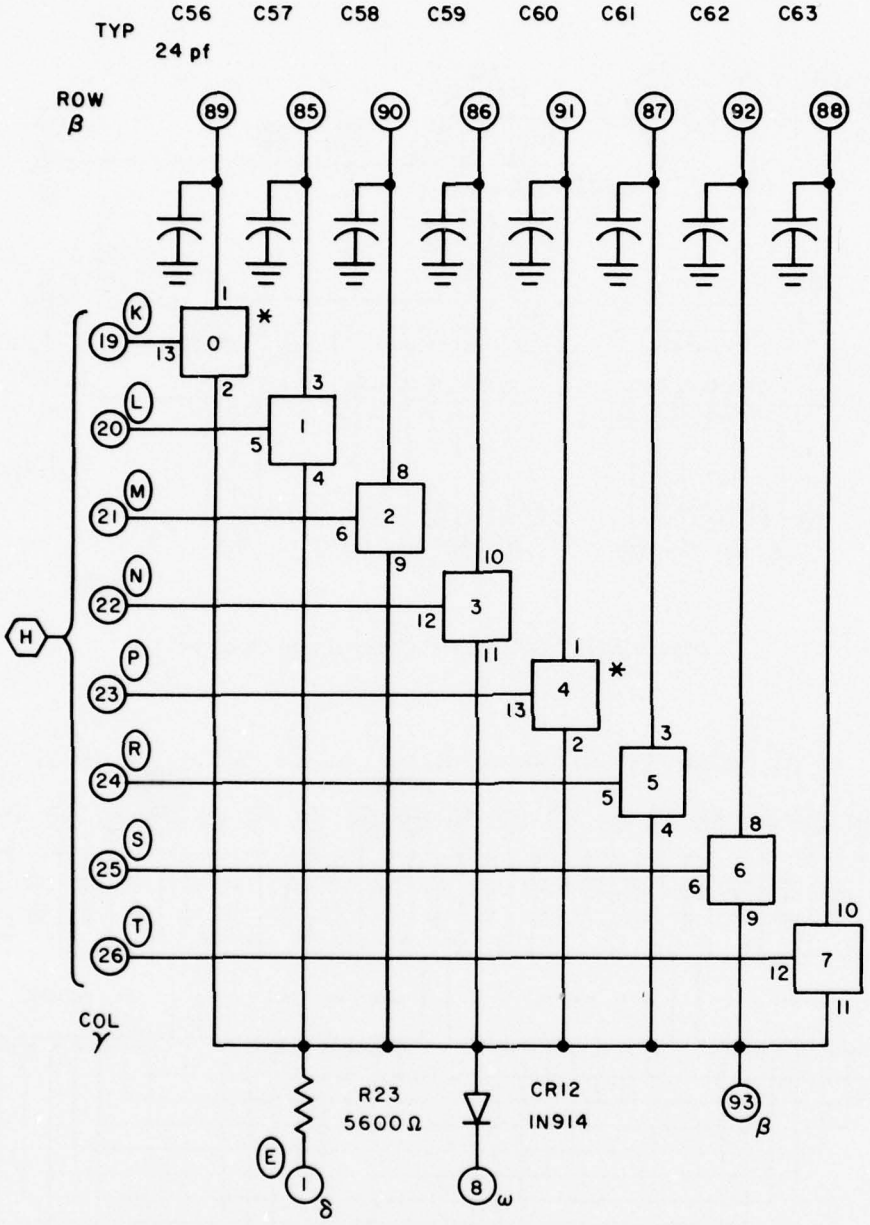
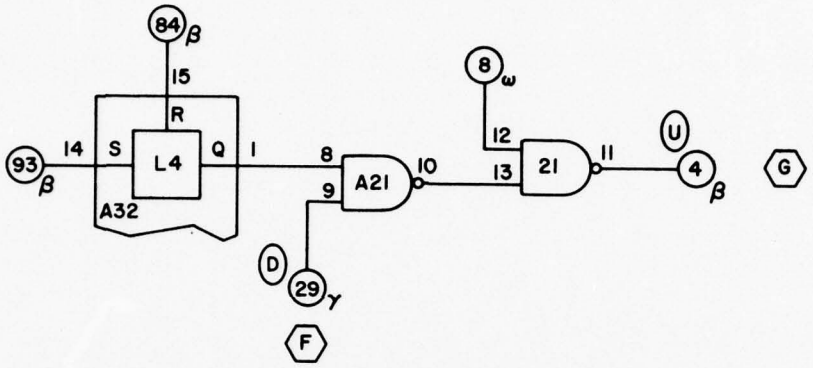


Figure A7c. Subtractor Switch



NOTE: A32 GROUND PINS 3, 4, 6, 7, 8, 11, 12

BOARD 3

Figure A7d. Subtractor Latch, Gate and Inverter

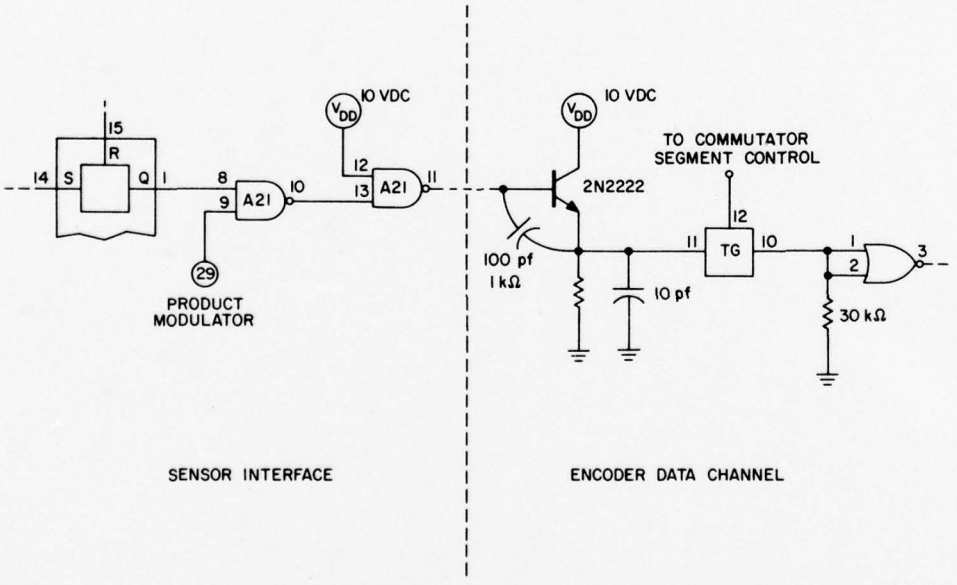


Figure A8. Interface/Encoder Interconnection

Appendix B

Parts Layouts

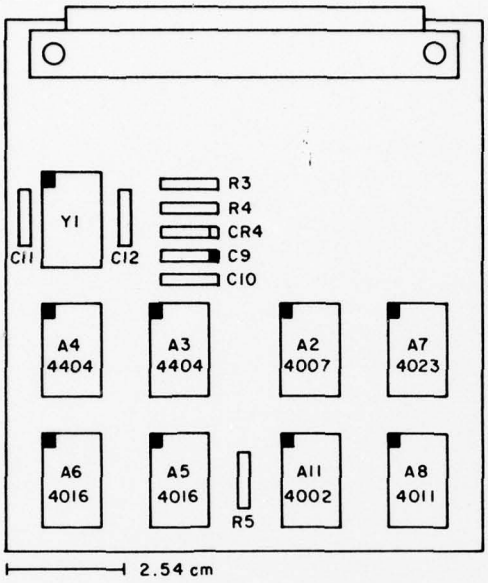


Figure B1. Board 1, Top View

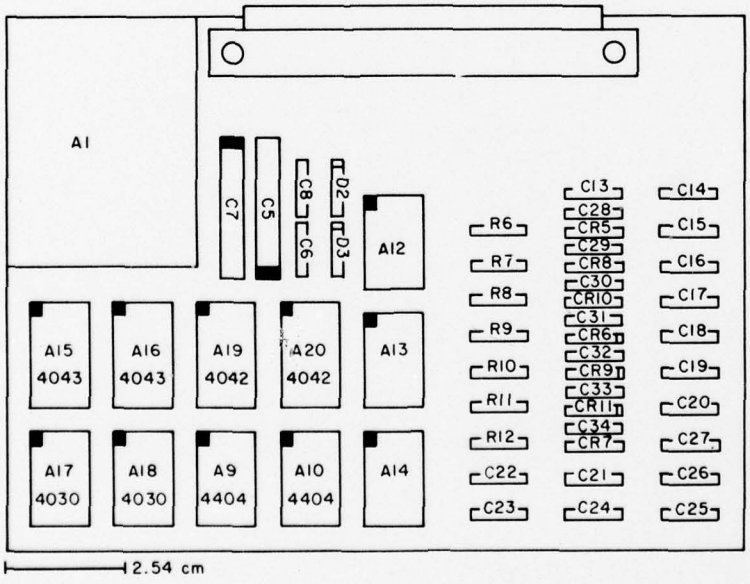


Figure B2. Board 2, Top View

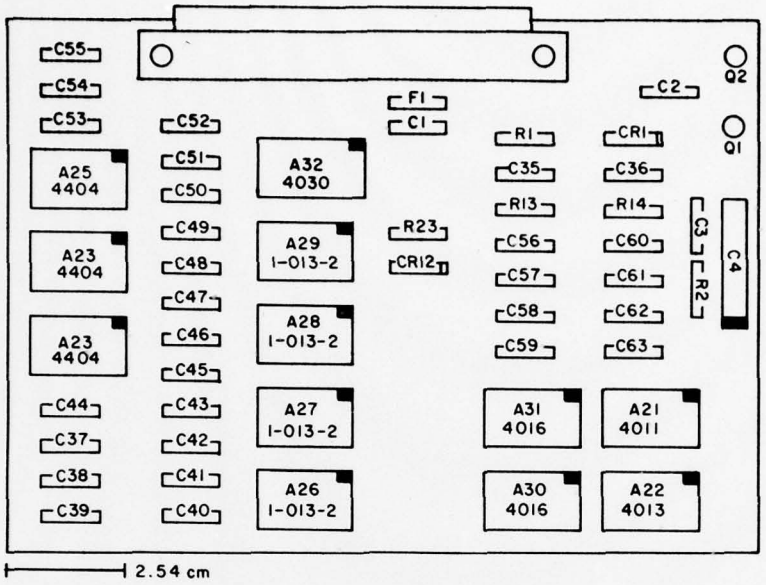


Figure B3. Board 3, Top View

Table B1. Interface Chassis Wiring

Pin	Connector					
	board number			external (0)	sensor (X)	sensor pin
	1	2	3			
A	3-A		1-A, 2-R	3-J	gnd	1
B	2-C		0-C		2-S	2
C		1-B	1-U	3-B	2-T	3
D	3-D	1-S	1-D		1-K	4
E	2-L, 3-K	1-R	2-S	3-U		5
F	3-F	1-T	1-F			6
H	2-K, 3-L	1-M	2-U	gnd		7
J	2-J, 3-M	1-J	0-A		gnd	8
K	X-4	1-H	1-E			9
L	2-M, 3-N	1-E	1-H			
M	2-H, 3-P	1-L	1-J			
N	2-N	1-N	1-L			
P	2-P	1-P	1-M			
R	2-E, 3-R	3-A	1-R			
S	2-D, 3-S	X-2, 3-E	1-S			
T	2-F, 3-T	X-3	1-T			
U	3-C	3-H	0-E			
V	gnd	gnd	gnd			

Note: Ground (gnd) represents ground lug on chassis.

Appendix C

Computer Program for Dictionary

```
PROGRAM HSALT      74/74   OPT=1                FTN 4.6+428        12/13/77  12.37.47

      PROGRAM HSALT(INPUT,OUTPUT)
      DIMENSION LETTR(8),ISB(8),A(5),HM(8),HF(8),B(2)
      DATA LETTR/1HS,1HU,1HR,1HW,1HD,1HK,1HG,1HO/
      READ 121,SN,A,B
  121 FORMAT(1A10,5F10.5,2F10.5)
      READ 120,ISB
  120 FORMAT(8I10)
      PRINT 700
  700 FORMAT(1H1,5X,"THE INPUT DATA ARE FOR HAMILTON STANDARD DIGITAL PR
     1ESSURE")
      PRINT 701,SN
  701 FORMAT(1H0,5X,"TRANSDUCER MODEL 10 P/N 752200 S/N",1A10,". THE CON
     1STANTS")
      PRINT 702
  702 FORMAT(1H0,5X,"FOR THE SENSOR CALIBRATION EQUATION")
      PRINT 730
  730 FORMAT(1H0,28X,"Y=-B(0)+B(1)*PERIOD")
      PRINT 731
  731 FORMAT(1H0,6X,"ARE")
      PRINT 732,B(1)
  732 FORMAT(1HJ,31X,"B(0)=",F10.5)
      PRINT 733,B(2)
  733 FORMAT(1HJ,31X,"B(1)=",F10.5)
      PRINT 734
  734 FORMAT(1HJ,5X,"AND FOR")
      PRINT 705
  705 FORMAT(1H0,39X,"2",4X,"3",4X,"4")
      PRINT 703
  703 FORMAT(1H ,25X,"PSIA=A-B*Y+C*Y -D*Y +E*Y ")
      PRINT 710
  710 FORMAT(1H0,5X,"ARE")
      PRINT 703,A(1)
  703 FORMAT(1HJ,31X,"A=",F10.5)
      PRINT 704,A(2)
  704 FORMAT(1H0,31X,"B=",F10.5)
      PRINT 705,A(3)
  705 FORMAT(1H0,31X,"C=",F10.5)
      PRINT 706,A(4)
  706 FORMAT(1H0,31X,"D=",F10.5)
      PRINT 707,A(5)
  707 FORMAT(1H0,31X,"E=",F10.5)
      PRINT 711
  711 FORMAT(1H0,5X,"THE SUBTRAHENDS FOR THE EIGHT SCALES ARE")
      PRINT 712,ISB(1)
  712 FORMAT(1H0,28X,"SCALE 0#",I10)
      PRINT 713,ISB(2)
  713 FORMAT(1HJ,28X,"SCALE 1#",I10)
      PRINT 714,ISB(3)
  714 FORMAT(1H0,28X,"SCALE 2#",I10)
      PRINT 715,ISB(4)
  715 FORMAT(1H0,28X,"SCALE 3#",I10)
      PRINT 716,ISB(5)
  716 FORMAT(1H0,28X,"SCALE 4#",I10)
      PRINT 717,ISB(6)
  717 FORMAT(1HJ,28X,"SCALE 5#",I10)
      PRINT 718,ISB(7)
  718 FORMAT(1H0,28X,"SCALE 6#",I10)
```

```
      PROGRAM HSALT      74/74   OPT=1                    FTN 4.6+628        12/13/77  12.37.47

                  PRINT 719,ISB(8)
            719   FORMAT(1H0,28X,"SCALE 7",I10)
                  PRINT 720
            720   FORMAT(1H0,5X,"THE EQUATION AND CONSTANTS WHICH DEFINE THE U.S. ST
                 1ANDARD")
                  PRINT 721
            721   FORMAT(1H0,5X,"ATMOSPHERE,1976 TO 47 KM ARE EMBEDDED IN THE PROGRA
                 1M.")
                  IPG=0
                  DO 100 ISC=1,8
                  IBK=0
                  ITC=ISB(ISC)
                  N=ISC+3
                  DO 500 IL=1,4
                  IPG=IPG+1
                  PRINT 101,SN,IPG
            101   FORMAT(1H1,6X,"GEOPOTENTIAL ALTITUDE VERSUS CODE",8X,"SN",1A10,8X,
                 1"PAGE",I3,20X,"AVERAGE RESOLUTION")
                  PRINT 102
            102   FORMAT(1H0,30X,"ALTITUDE: KILOMETERS",50X,"METERS")
                  PRINT 106
            106   FORMAT(1H ,40X,"KILOFEET",53X,"FEET")
                  PRINT 103,LETTR
            103   FORMAT(1HJ,5X,8(7X,A1))
                  DO 400 JP=1,2
                  IBK=IBK+1
                  PRINT 104
            104   FORMAT(1H )
                  PRINT 105
            105   FORMAT(1H )
                  DO 304 J4=1,8
                  DO 200 J4=1,6
                  PD=ITC/2.**N
                  Y=PD*B(2)-B(1)
                  PP=(A(1)-A(2)*Y+A(3)*Y**2-A(4)*Y**3+A(5)*Y**4)*68.947
                  IF(226.321-PP)201,201,202
            201   BH=0.0
                  BT=288.15
                  BL=-6.5
                  BPR=1013.25
                  GO TO 210
            202   IF(54.7493-PP)203,203,204
            203   BH=11.0
                  BT=216.65
                  BL=0.0001
                  BPR=226.321
                  GO TO 210
            204   IF(3.68013-PP)205,205,206
            205   BH=20.0
                  BT=216.65
                  BL=1.0
                  BPR=54.7493
                  GO TO 210
            206   IF(1.1090-PP)207,207,100
            207   BH=32.0
                  BT=228.65
                  BL=2.8
```

```
      PROGRAM HSALT      74/74   OPT=1                    FTN 4.6+428      12/13/77  12.37.47

115                 BPR=8.68019
                    GO TO 210
                210 HM(J4)=34+(3T*((PR/BPR)**(-BL/34.1632)-1))/BL
                    HF(J4)=HM(J4)/0.3048
                200 ITC=ITC+1
120                 ARESM=(HM(8)-HM(1))*1000./7
                    ARESF=(HF(8)-HF(1))*1000./7
                300 PRINT 301,LETTR(ISC),LETTR(IBK),LETTR(J3),HM,ARESM
                301 FORMAT(1H ,5X,3A1,1X,8F8.2,27X,F5.1)
                    PRINT 302,HF,ARESF
125             302 FORMAT(11X,6F8.2,27X,F5.1)
                304 PRINT 303
                303 FORMAT(1H )
                400 CONTINUE
                500 CONTINUE
130             100 CONTINUE
                    STOP
                    END
```

LOAD MAP - HSALT CYBER LOADER 1.1-428 12/13/77 12.38.00. PAGE 1

FWA OF THE LOAD 111
LWA+1 OF THE LOAD 20360

TRANSFER ADDRESS -- HSALT 4223

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR	VER LEVEL	HARDWARE	COMMENTS
HSALT	111	5204	LGO	12/13/77	FTN	4.6 428	666X I	OPT=1
/STP.END/	5315	1						
/FCL.C./	5316	23						
/QS.IO./	5341	133						
QENTRY=	5474	0	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		FCL INITILALIZATION ROUTINE.
COMIO=	5474	54	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMMON CODED I/O ROUTINES AND CONSTANTS.
FEQMSK=	5560	41	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		INITIALIZE CONSTANTS.
FLTOUT=	5621	511	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMMON FLOATING OUTPUT CODE
FORSYS=	6132	603	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		FORTRAN OBJECT LIBRARY UTILITIES.
INCOM=	6735	275	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMMON INPUT FORMATTING CODE
INPC=	7233	150	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		FORMATTED READ FORTRAN RECORD.
KODER=	7413	436	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		OUTPUT FORMAT INTERPRETER.
OUTCOM=	10071	154	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMMON OUTPUT CODE
ALOG	10245	73	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMPUYE COMMON AND NATURAL LOGARITHMS. OPT=ALL
EXP	10340	75	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		EXPONENTIAL FUNCTION. E TO POWER X. OPT=ALL.
SYSAID=	10435	1	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		LINK BETWEEN SYS=AID AND INITIALIZATION CODE.
FLTIN=	10436	154	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		COMMON FLOATING INPUT CONVERTER.
FMTAP=	10612	352	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		CRACK APLIST AND FORMAT FOR KODER/KRAKER.
FORUTL=	11164	16	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		FCL MISC. UTILITIES.
GETFIT=	11202	42	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		LOCATE AN FIT GIVEN A FILE NAME.
KRAKER=	11244	406	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		PROCESS FORMATTED FORTRAN INPUT.
OUTC=	11652	172	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		FORMATTED WRITE FORTRAN RECORD.
SYS=1ST	12044	52	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		MATH LIBRARY LINK TO ERROR MESSAGE PROCESSOR.
XTJI=	12125	10	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		REAL TO INTEGER EXPONENTIATION.
XTJY=	12136	7	SL-FORTRAN	08/12/77	COMPASS	3. 3-428		REAL TO REAL EXPONENTIATION.
/CON.RM/	12145	6						
CIO.RM	12153	40	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/ADB.RM/	12213	10						
MOVE.RM	12223	54	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
MCT.RM	12307	233	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/U1PS.RM/	12542	11						
/MEMC.RM/	12553	3						
/OPES.FO/	12556	1						
/OPEN.FO/	12557	7						
OPEN.RM	12566	237	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/TERM.RM/	13025	1						
/PUT.FO/	13026	7						
PUT.SQ	13035	1400	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
WAR.SQ	14435	260	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/CLSF.FO/	14715	7						
CLSF.RM	14724	25	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/GET.BT/	14751	5						
BTRT.SQ	14756	115	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
WEOX.SQ	15073	150	SL-SYSIO	09/03/76	COMPASS	3. 2-414		
/SKFL.FO/	15243	7						

LOAD MAP - HSALT CYBER LOADER 1.1-428 12/13/77 12.38.00.

SKFL.SQ	15252	51	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
ERR.RM	15323	404	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
CHWR.SQ	15727	7	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
OSUB.RM	15736	71	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
OPEN.SQ	16027	254	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
OPEX.SQ	16303	14	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
/PUT.RT/	16317	11				
RLEQ.RM	16330	42	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
CLSF.SQ	16372	134	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
/CLSV.FO/	16526	7				
CLSV.SQ	16535	137	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
/REW.FO/	16674	7				
REW.SQ	16703	33	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
/GET.FO/	16736	7				
/GET.RT/	16745	11				
GET.SQ	16756	1134	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
Z.SQ	20112	101	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
FSJ.SQ	20213	105	SL-SYSIO	09/03/76	COMPASS 3. 2-414	
SYS.RM	20321	37	SL-NUCLEUS	04/15/77	COMPASS 3. 2-414	PROCESS SYSTEM REQUEST.

.521 CP SECONDS 33000B CM STORAGE USED 26 TABLE MOVES

THE INPUT DATA ARE FOR HAMILTON STANDARD DIGITAL PRESSURE TRANSDUCER MODEL 1D P/N 752200 S/N FE39190. THE CONSTANTS FOR THE SENSOR CALIBRATION EQUATION

$$Y=-B(0)+B(1)*PERIOD$$

ARE

B(0) = 8.40000

B(1) = .04000

AND FOR

$$PSIA=A-B*Y+C*Y^2-D*Y^3+E*Y^4$$

ARE

A= 3.64276

B= 3.57956

C= 2.06373

D= .32116

E= .06544

THE SUBTRAHENDS FOR THE EIGHT SCALES ARE

SCALE 0: 3100

SCALE 1: 7000

SCALE 2: 14750

SCALE 3: 30000

SCALE 4: 60500

SCALE 5: 121600

SCALE 6: 243800

SCALE 7: 488100

THE EQUATION AND CONSTANTS WHICH DEFINE THE U.S. STANDARD ATMOSPHERE,1976 TO 47 KM ARE EMBEDDED IN THE PROGRAM.

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 1 AVERAGE RESOLUTION

ALTITUDE: KILOMETERS
KILOFEET

METERS
FEET

	S	U	R	W	D	K	G	O	
SSS	-.64	-.62	-.60	-.59	-.57	-.55	-.53	-.52	17.2
	-2.09	-2.03	-1.98	-1.92	-1.87	-1.81	-1.75	-1.70	56.5
SSU	-.50	-.48	-.46	-.45	-.43	-.41	-.40	-.38	17.3
	-1.64	-1.58	-1.53	-1.47	-1.41	-1.36	-1.30	-1.24	56.8
SSR	-.36	-.34	-.33	-.31	-.29	-.27	-.26	-.24	17.4
	-1.18	-1.13	-1.07	-1.01	-.96	-.90	-.84	-.79	57.0
SSW	-.22	-.20	-.19	-.17	-.15	-.13	-.12	-.10	17.5
	-.73	-.67	-.61	-.56	-.50	-.44	-.38	-.33	57.3
SSO	-.08	-.06	-.05	-.03	-.01	.01	.02	.04	17.5
	-.27	-.21	-.15	-.10	-.04	.02	.08	.13	57.5
SSK	.06	.08	.09	.11	.13	.15	.16	.18	17.6
	.19	.25	.31	.36	.42	.48	.54	.59	57.8
SSG	.20	.22	.23	.25	.27	.29	.31	.32	17.7
	.65	.71	.77	.83	.88	.94	1.00	1.06	58.1
SSO	.34	.36	.38	.39	.41	.43	.45	.47	17.8
	1.12	1.18	1.23	1.29	1.35	1.41	1.47	1.53	58.4
SUS	.48	.50	.52	.54	.55	.57	.59	.61	17.9
	1.58	1.64	1.70	1.76	1.82	1.88	1.94	2.00	58.6
SUU	.63	.64	.66	.68	.70	.72	.73	.75	18.0
	2.05	2.11	2.17	2.23	2.29	2.35	2.41	2.47	58.9
SUR	.77	.79	.81	.82	.84	.86	.88	.90	18.1
	2.53	2.58	2.64	2.70	2.76	2.82	2.88	2.94	59.3
SUW	.91	.93	.95	.97	.99	1.01	1.02	1.04	18.2
	3.00	3.06	3.12	3.18	3.24	3.30	3.36	3.42	59.6
SUO	1.06	1.08	1.10	1.11	1.13	1.15	1.17	1.19	18.3
	3.48	3.54	3.60	3.66	3.72	3.78	3.84	3.90	59.9
SUK	1.21	1.22	1.24	1.26	1.28	1.30	1.32	1.33	18.4
	3.96	4.02	4.08	4.14	4.20	4.26	4.32	4.38	60.2
SUG	1.35	1.37	1.39	1.41	1.43	1.44	1.46	1.48	18.5
	4.44	4.50	4.56	4.62	4.68	4.74	4.80	4.86	60.6
SUO	1.50	1.52	1.54	1.56	1.57	1.59	1.61	1.63	18.6
	4.92	4.98	5.04	5.11	5.17	5.23	5.29	5.35	61.0

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 2			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	O	
SRS	1.65	1.67	1.69	1.71	1.72	1.74	1.76	1.78	18.7
	5.41	5.47	5.53	5.59	5.66	5.72	5.78	5.84	61.3
SRU	1.80	1.82	1.84	1.86	1.87	1.89	1.91	1.93	18.8
	5.90	5.96	6.02	6.09	6.15	6.21	6.27	6.33	61.7
SRR	1.95	1.97	1.99	2.01	2.02	2.04	2.06	2.08	18.9
	6.40	6.46	6.52	6.58	6.64	6.71	6.77	6.83	62.1
SRW	2.10	2.12	2.14	2.16	2.18	2.20	2.22	2.23	19.1
	6.89	6.95	7.02	7.08	7.14	7.20	7.27	7.33	62.5
SRO	2.25	2.27	2.29	2.31	2.33	2.35	2.37	2.39	19.2
	7.39	7.46	7.52	7.58	7.64	7.71	7.77	7.83	62.9
SRK	2.41	2.43	2.45	2.46	2.48	2.50	2.52	2.54	19.3
	7.90	7.96	8.02	8.09	8.15	8.21	8.28	8.34	63.4
SRG	2.56	2.58	2.60	2.62	2.64	2.66	2.68	2.70	19.5
	8.40	8.47	8.53	8.59	8.66	8.72	8.79	8.85	63.8
SRO	2.72	2.74	2.76	2.78	2.80	2.81	2.83	2.85	19.6
	8.91	8.98	9.04	9.11	9.17	9.24	9.30	9.36	64.3
SWS	2.87	2.89	2.91	2.93	2.95	2.97	2.99	3.01	19.7
	9.43	9.49	9.55	9.62	9.69	9.75	9.82	9.88	64.8
SWU	3.03	3.05	3.07	3.09	3.11	3.13	3.15	3.17	19.9
	9.95	10.01	10.08	10.14	10.21	10.27	10.34	10.40	65.3
SWR	3.19	3.21	3.23	3.25	3.27	3.29	3.31	3.33	20.1
	10.47	10.54	10.60	10.67	10.73	10.80	10.86	10.93	65.8
SWW	3.35	3.37	3.39	3.41	3.43	3.45	3.47	3.49	20.2
	11.00	11.06	11.13	11.19	11.26	11.33	11.39	11.46	66.3
SWO	3.51	3.53	3.55	3.57	3.59	3.62	3.64	3.66	20.4
	11.53	11.59	11.65	11.73	11.79	11.86	11.93	12.00	66.9
SWK	3.68	3.70	3.72	3.74	3.76	3.78	3.80	3.82	20.6
	12.06	12.13	12.20	12.26	12.33	12.40	12.47	12.53	67.4
SWG	3.84	3.86	3.88	3.90	3.92	3.94	3.97	3.99	20.7
	12.60	12.67	12.74	12.81	12.87	12.94	13.01	13.08	68.8
SWO	4.01	4.03	4.05	4.07	4.09	4.11	4.13	4.15	20.9
	13.15	13.21	13.28	13.35	13.42	13.49	13.56	13.63	68.6

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 3			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	J	
SDS	4.17 13.70	4.20 13.76	4.22 13.83	4.24 13.90	4.26 13.97	4.28 14.04	4.30 14.11	4.32 14.18	21.1 69.3
SDU	4.34 14.25	4.36 14.32	4.39 14.39	4.41 14.46	4.43 14.53	4.45 14.60	4.47 14.67	4.49 14.74	21.3 69.9
SDR	4.51 14.81	4.54 14.88	4.56 14.95	4.58 15.02	4.60 15.09	4.62 15.16	4.64 15.23	4.66 15.30	21.5 70.6
SDW	4.69 15.38	4.71 15.45	4.73 15.52	4.75 15.59	4.77 15.66	4.80 15.73	4.82 15.80	4.84 15.87	21.7 71.3
SDD	4.86 15.95	4.88 16.02	4.90 16.09	4.93 16.16	4.95 16.23	4.97 16.31	4.99 16.38	5.01 16.45	22.0 72.1
SDK	5.04 16.52	5.06 16.60	5.08 16.67	5.10 16.74	5.12 16.81	5.15 16.89	5.17 16.96	5.19 17.03	22.2 72.8
SDG	5.21 17.11	5.24 17.18	5.26 17.25	5.28 17.33	5.30 17.40	5.33 17.47	5.35 17.55	5.37 17.62	22.4 73.6
SDO	5.39 17.70	5.42 17.77	5.44 17.84	5.46 17.92	5.48 17.99	5.51 18.07	5.53 18.14	5.55 18.22	22.7 74.4
SKS	5.58 18.29	5.60 18.37	5.62 18.44	5.64 18.52	5.67 18.59	5.69 18.67	5.71 18.74	5.74 18.82	22.9 75.3
SKU	5.76 18.89	5.78 18.97	5.81 19.05	5.83 19.12	5.85 19.20	5.87 19.27	5.90 19.35	5.92 19.43	23.2 76.2
SKR	5.94 19.50	5.97 19.58	5.99 19.65	6.02 19.73	6.04 19.81	6.06 19.89	6.09 19.97	6.11 20.04	23.5 77.1
SKW	6.13 20.12	6.16 20.20	6.18 20.28	6.20 20.35	6.23 20.43	6.25 20.51	6.28 20.59	6.30 20.67	23.8 78.1
SKD	6.32 20.75	6.35 20.83	6.37 20.90	6.40 20.98	6.42 21.06	6.44 21.14	6.47 21.22	6.49 21.30	24.1 79.1
SKK	6.52 21.38	6.54 21.46	6.57 21.54	6.59 21.62	6.61 21.70	6.64 21.78	6.66 21.86	6.69 21.94	24.4 80.1
SKG	6.71 22.02	6.74 22.10	6.76 22.18	6.79 22.26	6.81 22.35	6.84 22.43	6.86 22.51	6.89 22.59	24.8 81.3
SKO	6.91 22.67	6.94 22.75	6.96 22.84	6.99 22.92	7.01 23.00	7.04 23.08	7.06 23.17	7.09 23.25	25.1 82.4

GEOPOTENTIAL ALTITUDE VERSUS CODE					SN FE39190		PAGE 4		AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
SGS	7.11	7.14	7.16	7.19	7.21	7.24	7.26	7.29	25.5
	23.33	23.42	23.50	23.58	23.67	23.75	23.83	23.92	83.6
SGU	7.32	7.34	7.37	7.39	7.42	7.44	7.47	7.50	25.9
	24.00	24.09	24.17	24.26	24.34	24.42	24.51	24.60	84.9
SGR	7.52	7.55	7.58	7.60	7.63	7.65	7.68	7.71	26.3
	24.68	24.77	24.85	24.94	25.02	25.11	25.20	25.28	86.2
SGW	7.73	7.76	7.79	7.81	7.84	7.87	7.89	7.92	26.7
	25.37	25.46	25.55	25.63	25.72	25.81	25.90	25.98	87.6
SGD	7.95	7.97	8.00	8.03	8.06	8.08	8.11	8.14	27.1
	26.07	26.16	26.25	26.34	26.43	26.52	26.61	26.70	89.1
SGK	8.16	8.19	8.22	8.25	8.27	8.30	8.33	8.36	27.6
	26.79	26.88	26.97	27.06	27.15	27.24	27.33	27.42	90.6
SGG	8.39	8.41	8.44	8.47	8.50	8.53	8.55	8.58	28.1
	27.51	27.60	27.69	27.79	27.88	27.97	28.06	28.16	92.2
SGO	8.61	8.64	8.67	8.70	8.72	8.75	8.78	8.81	28.6
	28.25	28.34	28.44	28.53	28.62	28.72	28.81	28.91	93.9
SDS	8.84	8.87	8.90	8.93	8.96	8.99	9.01	9.04	29.2
	29.00	29.10	29.19	29.29	29.38	29.48	29.58	29.67	95.7
SDU	9.07	9.10	9.13	9.16	9.19	9.22	9.25	9.28	29.8
	29.77	29.87	29.96	30.06	30.16	30.26	30.35	30.45	97.6
SDR	9.31	9.34	9.37	9.40	9.43	9.46	9.49	9.52	30.4
	30.55	30.65	30.75	30.85	30.95	31.05	31.15	31.25	99.7
SDW	9.56	9.59	9.62	9.65	9.68	9.71	9.74	9.77	31.0
	31.35	31.45	31.55	31.65	31.75	31.86	31.96	32.06	101.8
SDD	9.80	9.84	9.87	9.90	9.93	9.96	9.99	10.03	31.7
	32.16	32.27	32.37	32.48	32.58	32.68	32.79	32.89	104.1
SDK	10.06	10.09	10.12	10.15	10.19	10.22	10.25	10.29	32.5
	33.00	33.10	33.21	33.32	33.42	33.53	33.64	33.74	106.5
SDG	10.32	10.35	10.38	10.42	10.45	10.48	10.52	10.55	33.3
	33.85	33.96	34.07	34.18	34.29	34.40	34.51	34.62	109.1
SDO	10.58	10.62	10.65	10.69	10.72	10.75	10.79	10.82	34.1
	34.73	34.84	34.95	35.06	35.17	35.28	35.40	35.51	111.9

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 5 AVERAGE RESOLUTION

ALTITUDE: KILOMETERS / METERS
KILOFEET / FEET

	S	U	R	W	D	K	G	O	
USS	7.52	7.54	7.55	7.56	7.58	7.59	7.60	7.61	13.1
	24.68	24.72	24.77	24.81	24.85	24.90	24.94	24.98	43.0
USU	7.63	7.64	7.65	7.67	7.68	7.69	7.71	7.72	13.2
	25.02	25.07	25.11	25.15	25.20	25.24	25.28	25.33	43.3
USR	7.73	7.75	7.76	7.77	7.79	7.80	7.81	7.83	13.3
	25.37	25.41	25.46	25.50	25.55	25.59	25.63	25.68	43.6
USW	7.84	7.85	7.87	7.88	7.89	7.91	7.92	7.93	13.4
	25.72	25.76	25.81	25.85	25.90	25.94	25.98	26.03	44.0
USO	7.95	7.96	7.97	7.99	8.00	8.01	8.03	8.04	13.5
	26.07	26.12	26.15	26.21	26.25	26.29	26.34	26.38	44.4
USK	8.06	8.07	8.08	8.10	8.11	8.12	8.14	8.15	13.6
	26.43	26.47	26.52	26.56	26.61	26.65	26.70	26.74	44.7
USG	8.16	8.18	8.19	8.21	8.22	8.23	8.25	8.26	13.8
	26.79	26.83	26.89	26.92	26.97	27.01	27.06	27.10	45.1
USO	8.27	8.29	8.30	8.32	8.33	8.34	8.36	8.37	13.9
	27.15	27.19	27.24	27.28	27.33	27.37	27.42	27.47	45.5
UUS	8.39	8.40	8.41	8.43	8.44	8.46	8.47	8.48	14.0
	27.51	27.56	27.60	27.65	27.69	27.74	27.79	27.83	45.9
UUU	8.50	8.51	8.53	8.54	8.55	8.57	8.58	8.60	14.1
	27.83	27.93	27.97	28.02	28.06	28.11	28.16	28.20	46.3
UUR	8.61	8.62	8.64	8.65	8.67	8.68	8.70	8.71	14.3
	28.25	28.30	28.34	28.39	28.44	28.48	28.53	28.58	46.8
UUW	8.72	8.74	8.75	8.77	8.78	8.80	8.81	8.83	14.4
	28.62	28.67	28.72	28.77	28.81	28.86	28.91	28.95	47.2
UUO	8.84	8.85	8.87	8.88	8.90	8.91	8.93	8.94	14.5
	29.00	29.05	29.10	29.14	29.19	29.24	29.29	29.34	47.7
UUK	8.36	8.37	8.39	9.00	9.01	9.03	9.04	9.06	14.7
	29.38	29.43	29.48	29.53	29.58	29.62	29.67	29.72	48.1
UUG	9.07	9.09	9.10	9.12	9.13	9.15	9.16	9.18	14.8
	29.77	29.82	29.87	29.91	29.96	30.01	30.06	30.11	48.6
UUO	9.13	9.21	9.22	9.24	9.25	9.27	9.28	9.30	15.0
	30.16	30.21	30.26	30.30	30.35	30.40	30.45	30.50	49.1

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 6			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
URS	9.31	9.33	9.34	9.36	9.37	9.39	9.40	9.42	15.1
	30.55	30.60	30.65	30.70	30.75	30.80	30.85	30.90	49.6
URU	9.43	9.45	9.46	9.48	9.49	9.51	9.52	9.54	15.3
	30.95	31.00	31.05	31.10	31.15	31.20	31.25	31.30	50.1
URR	9.56	9.57	9.59	9.60	9.62	9.63	9.65	9.66	15.4
	31.35	31.40	31.45	31.50	31.55	31.60	31.65	31.70	50.7
URW	9.68	9.69	9.71	9.73	9.74	9.76	9.77	9.79	15.6
	31.75	31.81	31.86	31.91	31.96	32.01	32.06	32.11	51.2
URD	9.80	9.82	9.84	9.85	9.87	9.88	9.90	9.91	15.8
	32.16	32.22	32.27	32.32	32.37	32.42	32.48	32.53	51.8
URK	9.93	9.95	9.96	9.98	9.99	10.01	10.03	10.04	16.0
	32.58	32.63	32.68	32.74	32.79	32.84	32.89	32.95	52.4
URG	10.06	10.07	10.09	10.11	10.12	10.14	10.15	10.17	16.2
	33.00	33.05	33.10	33.16	33.21	33.26	33.32	33.37	53.0
URO	10.19	10.20	10.22	10.24	10.25	10.27	10.29	10.30	16.3
	33.42	33.48	33.53	33.58	33.64	33.69	33.74	33.80	53.6
UWS	10.32	10.33	10.35	10.37	10.38	10.40	10.42	10.43	16.5
	33.85	33.91	33.96	34.01	34.07	34.12	34.18	34.23	54.3
UWU	10.45	10.47	10.48	10.50	10.52	10.53	10.55	10.57	16.7
	34.29	34.34	34.40	34.45	34.51	34.56	34.62	34.67	54.9
UWR	10.55	10.60	10.62	10.64	10.65	10.67	10.69	10.70	17.0
	34.73	34.78	34.94	34.89	34.95	35.00	35.06	35.12	55.6
UWW	10.72	10.74	10.75	10.77	10.79	10.81	10.82	10.84	17.2
	35.17	35.23	35.29	35.34	35.40	35.45	35.51	35.57	56.4
UWD	10.86	10.88	10.89	10.91	10.93	10.94	10.96	10.98	17.4
	35.62	35.68	35.74	35.79	35.85	35.91	35.97	36.02	57.1
UWK	11.00	11.01	11.03	11.05	11.07	11.09	11.10	11.12	17.7
	36.08	36.14	36.20	36.25	36.31	36.37	36.43	36.49	58.0
UWG	11.14	11.16	11.17	11.19	11.21	11.23	11.25	11.26	18.0
	36.54	36.60	36.66	36.72	36.78	36.84	36.90	36.96	59.0
UWO	11.28	11.30	11.32	11.34	11.36	11.37	11.39	11.41	18.3
	37.02	37.08	37.14	37.20	37.26	37.32	37.38	37.44	60.1

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 7			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	M	D	K	G	O	
UJS	11.43	11.45	11.47	11.49	11.50	11.52	11.54	11.56	18.7
	37.50	37.56	37.62	37.68	37.74	37.80	37.87	37.93	61.3
UJU	11.58	11.60	11.62	11.64	11.66	11.67	11.69	11.71	19.0
	37.99	38.05	38.11	38.18	38.24	38.30	38.36	38.43	62.5
UJR	11.73	11.75	11.77	11.79	11.81	11.83	11.85	11.87	19.4
	38.49	38.55	38.62	38.68	38.74	38.81	38.87	38.94	63.7
UJM	11.89	11.91	11.93	11.95	11.97	11.99	12.01	12.03	19.8
	39.00	39.07	39.13	39.20	39.26	39.33	39.39	39.46	65.0
UJD	12.05	12.07	12.09	12.11	12.13	12.15	12.17	12.19	20.2
	39.52	39.59	39.65	39.72	39.79	39.85	39.92	39.99	66.4
UJK	12.21	12.23	12.25	12.27	12.29	12.31	12.33	12.35	20.7
	40.05	40.12	40.19	40.26	40.32	40.39	40.46	40.53	67.8
UJG	12.37	12.40	12.42	12.44	12.46	12.48	12.50	12.52	21.1
	40.60	40.67	40.74	40.80	40.87	40.94	41.01	41.08	69.3
UJO	12.54	12.56	12.59	12.61	12.63	12.65	12.67	12.69	21.6
	41.15	41.22	41.29	41.36	41.44	41.51	41.58	41.65	70.9
UKS	12.72	12.74	12.76	12.78	12.80	12.83	12.85	12.87	22.1
	41.72	41.79	41.86	41.94	42.01	42.08	42.16	42.23	72.6
UKU	12.89	12.92	12.94	12.96	12.98	13.01	13.03	13.05	22.6
	42.30	42.38	42.45	42.52	42.60	42.67	42.75	42.82	74.3
UKR	13.08	13.10	13.12	13.14	13.17	13.19	13.21	13.24	23.2
	42.90	42.97	43.05	43.12	43.20	43.28	43.35	43.43	76.1
UKM	13.26	13.28	13.31	13.33	13.36	13.38	13.40	13.43	23.8
	43.51	43.58	43.65	43.74	43.82	43.90	43.98	44.05	78.1
UKD	13.45	13.48	13.50	13.52	13.55	13.57	13.60	13.62	24.4
	44.13	44.21	44.29	44.37	44.45	44.53	44.61	44.69	80.1
UKK	13.65	13.67	13.70	13.72	13.75	13.77	13.80	13.82	25.1
	44.77	44.86	44.94	45.02	45.10	45.18	45.27	45.35	82.3
UKG	13.85	13.87	13.90	13.93	13.95	13.98	14.00	14.03	25.8
	45.43	45.52	45.60	45.69	45.77	45.86	45.94	46.03	84.6
UKO	14.05	14.08	14.11	14.13	14.16	14.19	14.21	14.24	26.5
	46.11	46.20	46.29	46.37	46.46	46.55	46.63	46.72	87.0

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 8			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
UGS	14.27	14.29	14.32	14.35	14.38	14.40	14.43	14.46	27.3
	46.81	46.90	46.99	47.08	47.17	47.26	47.35	47.44	89.6
UGU	14.49	14.51	14.54	14.57	14.60	14.63	14.65	14.68	28.2
	47.53	47.62	47.71	47.80	47.89	47.99	48.08	48.17	92.4
UGR	14.71	14.74	14.77	14.80	14.83	14.86	14.89	14.92	29.1
	48.27	48.36	48.46	48.55	48.65	48.74	48.84	48.94	95.3
UGW	14.94	14.97	15.00	15.03	15.06	15.09	15.12	15.16	30.0
	49.03	49.13	49.23	49.32	49.42	49.52	49.62	49.72	98.5
UGD	15.19	15.22	15.25	15.28	15.31	15.34	15.37	15.40	31.0
	49.82	49.92	50.02	50.12	50.23	50.33	50.43	50.53	101.9
UGK	15.43	15.47	15.50	15.53	15.56	15.59	15.63	15.66	32.2
	50.64	50.74	50.85	50.95	51.06	51.16	51.27	51.38	105.5
UGG	15.69	15.73	15.76	15.79	15.82	15.86	15.89	15.93	33.4
	51.48	51.59	51.70	51.81	51.92	52.03	52.14	52.25	109.4
UGO	15.96	15.99	16.03	16.06	16.10	16.13	16.17	16.20	34.7
	52.36	52.47	52.59	52.70	52.81	52.93	53.04	53.16	113.7
UOS	16.24	16.27	16.31	16.34	16.38	16.42	16.45	16.49	36.1
	53.27	53.39	53.51	53.62	53.74	53.86	53.98	54.10	118.3
UOU	16.53	16.56	16.60	16.64	16.68	16.71	16.75	16.79	37.6
	54.22	54.34	54.47	54.59	54.71	54.84	54.96	55.09	123.4
UOR	16.83	16.87	16.91	16.95	16.98	17.02	17.06	17.10	39.3
	55.21	55.34	55.47	55.59	55.72	55.85	55.98	56.11	128.9
UOW	17.14	17.18	17.23	17.27	17.31	17.35	17.39	17.43	41.1
	56.25	56.38	56.51	56.65	56.78	56.92	57.05	57.19	135.0
UOD	17.47	17.52	17.56	17.60	17.65	17.69	17.73	17.78	43.2
	57.33	57.47	57.61	57.75	57.89	58.03	58.18	58.32	141.7
UOK	17.82	17.87	17.91	17.96	18.00	18.05	18.09	18.14	45.4
	58.47	58.61	58.75	58.91	59.06	59.21	59.36	59.51	149.1
UOG	18.19	18.23	18.28	18.33	18.38	18.42	18.47	18.52	48.8
	59.66	59.82	59.97	60.13	60.29	60.44	60.60	60.76	157.4
UOO	18.57	18.62	18.67	18.72	18.77	18.82	18.87	18.93	50.8
	60.93	61.09	61.25	61.42	61.59	61.75	61.92	62.09	166.7

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190	PAGE 9				AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	J	
RSS	14.03	14.04	14.05	14.07	14.08	14.09	14.11	14.12	13.1
	46.03	46.07	46.11	46.16	46.20	46.24	46.28	46.33	43.1
RSU	14.13	14.15	14.16	14.17	14.19	14.20	14.21	14.23	13.3
	46.37	46.41	46.46	46.50	46.55	46.59	46.63	46.68	43.7
RSR	14.24	14.25	14.27	14.28	14.29	14.31	14.32	14.34	13.5
	46.72	46.77	46.81	46.85	46.90	46.94	46.99	47.03	44.3
RSW	14.35	14.36	14.38	14.39	14.40	14.42	14.43	14.44	13.7
	47.08	47.12	47.17	47.21	47.26	47.30	47.35	47.39	45.0
RSD	14.46	14.47	14.49	14.50	14.51	14.53	14.54	14.56	13.9
	47.44	47.48	47.53	47.57	47.62	47.66	47.71	47.76	45.7
RSK	14.57	14.58	14.60	14.61	14.63	14.64	14.65	14.67	14.1
	47.80	47.85	47.89	47.94	47.99	48.03	48.08	48.13	46.4
RSG	14.68	14.70	14.71	14.73	14.74	14.76	14.77	14.78	14.4
	48.17	48.22	48.27	48.31	48.36	48.41	48.46	48.50	47.1
RSQ	14.80	14.81	14.83	14.84	14.86	14.87	14.89	14.90	14.6
	48.55	48.60	48.65	48.69	48.74	48.79	48.84	48.89	47.9
RJS	14.92	14.93	14.94	14.96	14.97	14.99	15.00	15.02	14.8
	48.94	48.98	49.03	49.08	49.13	49.18	49.23	49.28	48.7
RJU	15.03	15.05	15.06	15.08	15.09	15.11	15.12	15.14	15.1
	49.32	49.37	49.42	49.47	49.52	49.57	49.62	49.67	49.5
RJR	15.16	15.17	15.19	15.20	15.22	15.23	15.25	15.26	15.3
	49.72	49.77	49.82	49.87	49.92	49.97	50.02	50.07	50.3
RJW	15.28	15.29	15.31	15.32	15.34	15.36	15.37	15.39	15.6
	50.12	50.18	50.23	50.28	50.33	50.38	50.43	50.48	51.2
RJD	15.40	15.42	15.43	15.45	15.47	15.48	15.50	15.51	15.9
	50.53	50.59	50.64	50.69	50.74	50.79	50.85	50.90	52.1
RJK	15.53	15.55	15.56	15.58	15.59	15.61	15.63	15.64	16.2
	50.95	51.00	51.06	51.11	51.16	51.22	51.27	51.32	53.0
RJG	15.66	15.68	15.69	15.71	15.73	15.74	15.76	15.77	16.5
	51.38	51.43	51.49	51.54	51.59	51.65	51.70	51.75	54.0
RJO	15.79	15.81	15.82	15.84	15.86	15.88	15.89	15.91	16.8
	51.81	51.86	51.92	51.97	52.03	52.08	52.14	52.19	55.8

GEOPOTENTIAL ALTITUDE VERSUS CODE					SN FE39190		PAGE 18		AVERAGE RESOLUTION
			ALTITUDE: KILOMETERS KILOFEET						METERS FEET
	S	U	R	W	O	K	G	O	
R2S	15.93	15.94	15.96	15.98	15.99	16.01	16.03	16.05	17.1
	52.25	52.31	52.36	52.42	52.47	52.53	52.59	52.64	56.1
R2U	16.06	16.08	16.10	16.11	16.13	16.15	16.17	16.18	17.4
	52.70	52.76	52.81	52.87	52.93	52.98	53.04	53.10	57.2
R2R	16.20	16.22	16.24	16.26	16.27	16.29	16.31	16.33	17.8
	53.16	53.22	53.27	53.33	53.39	53.45	53.51	53.57	58.3
R2W	16.34	16.36	16.38	16.40	16.42	16.44	16.45	16.47	18.1
	53.62	53.68	53.74	53.80	53.86	53.92	53.98	54.04	59.5
R2O	16.49	16.51	16.53	16.55	16.56	16.58	16.60	16.62	18.5
	54.10	54.16	54.22	54.28	54.34	54.41	54.47	54.53	60.8
R2K	16.64	16.66	16.68	16.70	16.71	16.73	16.75	16.77	18.9
	54.59	54.65	54.71	54.77	54.84	54.90	54.96	55.02	62.1
R2G	16.79	16.81	16.83	16.85	16.87	16.89	16.91	16.93	19.3
	55.09	55.15	55.21	55.28	55.34	55.40	55.47	55.53	63.5
R2O	16.95	16.96	16.98	17.00	17.02	17.04	17.06	17.08	19.8
	55.59	55.66	55.72	55.79	55.85	55.92	55.98	56.05	64.9
R4S	17.18	17.12	17.14	17.16	17.18	17.20	17.23	17.25	28.2
	56.11	56.18	56.25	56.31	56.38	56.45	56.51	56.58	66.4
R4U	17.27	17.29	17.31	17.33	17.35	17.37	17.39	17.41	20.7
	56.65	56.71	56.78	56.85	56.92	56.99	57.05	57.12	68.8
R4R	17.43	17.45	17.47	17.50	17.52	17.54	17.56	17.58	21.2
	57.19	57.26	57.33	57.40	57.47	57.54	57.61	57.68	69.6
R4W	17.60	17.62	17.65	17.67	17.69	17.71	17.73	17.75	21.8
	57.75	57.82	57.89	57.96	58.03	58.11	58.18	58.25	71.4
R4O	17.79	17.80	17.82	17.84	17.87	17.89	17.91	17.93	22.3
	58.32	58.39	58.47	58.54	58.61	58.69	58.76	58.83	73.2
R4K	17.96	17.98	18.00	18.02	18.05	18.07	18.09	18.12	22.9
	58.91	58.98	59.06	59.13	59.21	59.28	59.36	59.43	75.1
R4G	18.14	18.16	18.18	18.21	18.23	18.26	18.28	18.30	23.5
	59.51	59.59	59.66	59.74	59.82	59.89	59.97	60.05	77.2
R4O	18.33	18.35	18.38	18.40	18.42	18.45	18.47	18.50	24.2
	60.13	60.21	60.29	60.37	60.44	60.52	60.60	60.68	79.4

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 11

ALTITUDE: KILOMETERS
KILOFEET

	S	U	R	W	D	K	G	O	AVERAGE RESOLUTION METERS FEET
RDS	18.52	18.55	18.57	18.60	18.62	18.65	18.67	18.70	24.9
	60.76	60.85	60.93	61.01	61.09	61.17	61.25	61.34	81.7
RDU	18.72	18.75	18.77	18.80	18.82	18.85	18.87	18.90	25.6
	61.42	61.50	61.59	61.67	61.75	61.84	61.92	62.01	84.1
RDR	18.93	18.95	18.98	19.00	19.03	19.06	19.08	19.11	26.4
	62.09	62.19	62.27	62.35	62.44	62.53	62.61	62.70	86.7
RDM	19.14	19.16	19.19	19.22	19.25	19.27	19.30	19.33	27.3
	62.79	62.88	62.97	63.05	63.14	63.23	63.32	63.41	89.5
RDD	19.36	19.38	19.41	19.44	19.47	19.50	19.53	19.55	28.2
	63.51	63.60	63.69	63.78	63.87	63.97	64.06	64.15	92.4
RDK	19.58	19.61	19.64	19.67	19.70	19.73	19.76	19.79	29.1
	64.25	64.34	64.44	64.53	64.63	64.72	64.82	64.92	95.6
RDG	19.82	19.85	19.88	19.91	19.94	19.97	20.00	20.03	30.2
	65.01	65.11	65.21	65.31	65.41	65.51	65.61	65.71	99.0
RDO	20.06	20.09	20.12	20.15	20.18	20.21	20.25	20.28	31.3
	65.81	65.91	66.01	66.11	66.21	66.32	66.42	66.53	102.7
RKS	20.31	20.34	20.37	20.41	20.44	20.47	20.50	20.54	32.6
	66.63	66.74	66.84	66.95	67.05	67.16	67.27	67.38	106.8
RKU	20.57	20.60	20.64	20.67	20.70	20.74	20.77	20.81	33.9
	67.49	67.60	67.71	67.82	67.93	68.04	68.15	68.27	111.3
RKR	20.84	20.88	20.91	20.95	20.98	21.02	21.05	21.09	35.4
	68.38	68.49	68.61	68.72	68.84	68.96	69.07	69.19	116.1
RKW	21.13	21.16	21.20	21.24	21.27	21.31	21.35	21.38	37.0
	69.31	69.43	69.55	69.67	69.79	69.91	70.04	70.16	121.3
RKD	21.42	21.46	21.50	21.54	21.58	21.62	21.65	21.69	38.7
	70.28	70.41	70.53	70.66	70.79	70.92	71.04	71.17	127.1
RKK	21.73	21.77	21.81	21.85	21.89	21.94	21.98	22.02	40.7
	71.30	71.43	71.57	71.70	71.83	71.97	72.10	72.24	133.4
RKG	22.06	22.10	22.14	22.19	22.23	22.27	22.32	22.36	42.8
	72.37	72.51	72.65	72.79	72.93	73.07	73.21	73.36	140.4
RKO	22.40	22.45	22.49	22.54	22.58	22.63	22.67	22.72	45.2
	73.50	73.65	73.79	73.94	74.09	74.24	74.39	74.54	148.2

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39130		PAGE 12			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
RGS	22.77	22.81	22.85	22.91	22.96	23.00	23.05	23.10	47.8
	74.69	74.85	75.00	75.16	75.31	75.47	75.63	75.79	156.9
RGU	23.15	23.20	23.25	23.30	23.35	23.40	23.45	23.51	50.8
	75.95	76.11	76.28	76.44	76.61	76.78	76.95	77.12	166.7
RGR	23.56	23.61	23.66	23.72	23.77	23.83	23.88	23.94	54.2
	77.23	77.46	77.64	77.82	77.99	78.17	78.35	78.54	177.9
RGW	23.33	24.05	24.11	24.16	24.22	24.28	24.34	24.40	58.1
	78.72	78.91	79.09	79.28	79.47	79.66	79.86	80.05	190.6
RGD	24.46	24.52	24.58	24.64	24.71	24.77	24.83	24.90	62.6
	80.25	80.45	80.65	80.86	81.06	81.27	81.48	81.69	205.2
RGK	24.36	25.03	25.10	25.16	25.23	25.30	25.37	25.44	67.8
	81.90	82.12	82.33	82.55	82.78	83.00	83.23	83.46	222.4
RGG	25.51	25.58	25.65	25.73	25.80	25.87	25.95	26.03	74.0
	83.69	83.92	84.15	84.40	84.64	84.89	85.14	85.39	242.6
RGO	26.10	26.18	26.26	26.34	26.42	26.51	26.59	26.67	81.4
	85.64	85.90	86.18	86.42	86.69	86.96	87.23	87.51	266.9
RJS	26.76	26.85	26.93	27.02	27.11	27.20	27.30	27.39	90.4
	87.79	88.05	88.37	88.66	88.95	89.25	89.56	89.87	296.6
RJU	27.49	27.58	27.68	27.78	27.88	27.98	28.09	28.20	101.7
	90.18	90.50	90.82	91.15	91.49	91.82	92.17	92.52	333.8
RJR	28.31	28.42	28.53	28.64	28.76	28.88	29.00	29.12	116.3
	92.87	93.24	93.60	93.98	94.36	94.75	95.14	95.54	381.4
RJW	29.25	29.37	29.50	29.64	29.77	29.91	30.05	30.20	135.6
	95.95	96.37	96.80	97.23	97.68	98.13	98.60	99.07	444.9
RJD	30.34	30.49	30.65	30.81	30.97	31.14	31.31	31.48	162.6
	99.55	100.05	100.55	101.08	101.61	102.15	102.71	103.29	533.5
RJK	31.56	31.85	32.04	32.23	32.44	32.65	32.86	33.09	203.6
	103.88	104.49	105.11	105.76	106.42	107.11	107.82	108.56	668.8
RJG	33.32	33.56	33.81	34.07	34.35	34.63	34.93	35.24	274.5
	109.32	110.11	110.93	111.79	112.69	113.62	114.60	115.62	900.4
RJO	35.57	35.91	36.28	36.67	37.08	37.51	37.98	38.49	416.8
	116.78	117.33	119.03	120.30	121.64	123.08	124.62	126.27	*****

GEOPOTENTIAL ALTITUDE VERSUS CODE					SN FE39190		PAGE 13		AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	O	
WSS	18.35 60.29	18.39 60.33	18.40 60.37	18.41 60.40	18.42 60.44	18.44 60.48	18.45 60.52	18.46 60.56	12.1 39.7
WSU	18.47 60.60	18.48 60.64	18.50 60.68	18.51 60.72	18.52 60.76	18.53 60.81	18.55 60.85	18.56 60.89	12.3 40.3
WSR	18.57 60.93	18.58 60.97	18.60 61.01	18.61 61.05	18.62 61.09	18.63 61.13	18.65 61.17	18.66 61.21	12.5 40.9
WSW	18.67 61.25	18.69 61.30	18.70 61.34	18.71 61.38	18.72 61.42	18.73 61.46	18.75 61.50	18.76 61.54	12.6 41.5
WSO	18.77 61.59	18.78 61.63	18.80 61.67	18.81 61.71	18.82 61.75	18.84 61.80	18.85 61.84	18.86 61.88	12.8 42.1
WSK	18.87 61.92	18.89 61.97	18.90 62.01	18.91 62.05	18.93 62.09	18.94 62.14	18.95 62.18	18.97 62.22	13.0 42.7
WSG	18.98 62.27	18.99 62.31	19.00 62.35	19.02 62.39	19.03 62.44	19.04 62.48	19.06 62.53	19.07 62.57	13.2 43.4
WSO	19.08 62.61	19.10 62.66	19.11 62.70	19.12 62.74	19.14 62.79	19.15 62.83	19.16 62.88	19.18 62.92	13.4 44.1
WJS	19.19 62.97	19.21 63.01	19.22 63.05	19.23 63.10	19.25 63.14	19.26 63.19	19.27 63.23	19.29 63.28	13.6 44.8
WJU	19.30 63.32	19.31 63.37	19.33 63.41	19.34 63.46	19.36 63.51	19.37 63.55	19.38 63.60	19.40 63.64	13.9 45.5
WJR	19.41 63.69	19.43 63.73	19.44 63.78	19.45 63.83	19.47 63.87	19.48 63.92	19.50 63.97	19.51 64.01	14.1 46.3
WJW	19.53 64.06	19.54 64.11	19.55 64.15	19.57 64.20	19.58 64.25	19.60 64.29	19.61 64.34	19.63 64.39	14.3 47.0
WJO	19.64 64.44	19.65 64.48	19.67 64.53	19.68 64.58	19.70 64.63	19.71 64.67	19.73 64.72	19.74 64.77	14.6 47.8
WJK	19.76 64.82	19.77 64.87	19.79 64.92	19.80 64.96	19.82 65.01	19.83 65.06	19.85 65.11	19.86 65.16	14.8 48.7
WJG	19.88 65.21	19.89 65.26	19.91 65.31	19.92 65.36	19.94 65.41	19.95 65.46	19.97 65.51	19.98 65.56	15.1 49.6
WJO	20.00 65.61	20.01 65.66	20.03 65.71	20.04 65.76	20.06 65.81	20.07 65.86	20.09 65.91	20.10 65.96	15.4 50.5

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 14			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
WRS	20.12 66.01	20.14 66.06	20.15 66.11	20.17 66.16	20.18 66.21	20.20 66.27	20.21 66.32	20.23 66.37	15.7 51.4
WRU	20.25 66.42	20.26 66.47	20.28 66.53	20.29 66.58	20.31 66.63	20.33 66.68	20.34 66.74	20.36 66.79	16.0 52.4
WRR	20.37 66.84	20.39 66.89	20.41 66.95	20.42 67.00	20.44 67.05	20.45 67.11	20.47 67.16	20.49 67.22	16.3 53.5
WRW	20.50 67.27	20.52 67.32	20.54 67.38	20.55 67.43	20.57 67.49	20.59 67.54	20.60 67.60	20.62 67.65	16.6 54.6
WRD	20.64 67.71	20.65 67.76	20.67 67.82	20.69 67.87	20.70 67.93	20.72 67.98	20.74 68.04	20.76 68.10	17.0 55.7
WRK	20.77 68.15	20.79 68.21	20.81 68.27	20.82 68.32	20.84 68.38	20.86 68.44	20.88 68.49	20.89 68.55	17.3 56.9
WRG	20.91 68.61	20.93 68.67	20.95 68.72	20.96 68.78	20.98 68.84	21.00 68.90	21.02 68.96	21.04 69.02	17.7 58.1
WRO	21.05 69.07	21.07 69.13	21.09 69.19	21.11 69.25	21.13 69.31	21.14 69.37	21.16 69.43	21.18 69.49	18.1 59.4
WWS	21.21 69.55	21.22 69.61	21.24 69.67	21.25 69.73	21.27 69.79	21.29 69.85	21.31 69.91	21.33 69.98	18.5 60.7
WWU	21.35 70.04	21.37 70.10	21.38 70.16	21.40 70.22	21.42 70.28	21.44 70.35	21.46 70.41	21.48 70.47	18.9 62.1
WWR	21.50 70.53	21.52 70.60	21.54 70.66	21.56 70.72	21.58 70.79	21.60 70.85	21.62 70.92	21.63 70.98	19.4 63.6
WWW	21.65 71.04	21.67 71.11	21.69 71.17	21.71 71.24	21.73 71.30	21.75 71.37	21.77 71.43	21.79 71.50	19.9 65.2
WWD	21.81 71.57	21.83 71.63	21.85 71.70	21.87 71.77	21.89 71.83	21.92 71.90	21.94 71.97	21.96 72.03	20.4 66.8
WWK	21.98 72.10	22.00 72.17	22.02 72.24	22.04 72.31	22.06 72.37	22.08 72.44	22.10 72.51	22.12 72.58	20.9 68.5
WWG	22.14 72.65	22.17 72.72	22.19 72.79	22.21 72.86	22.23 72.93	22.25 73.00	22.27 73.07	22.29 73.14	21.4 70.3
WWO	22.32 73.21	22.34 73.29	22.36 73.36	22.38 73.43	22.40 73.50	22.43 73.57	22.45 73.65	22.47 73.72	22.0 72.2

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39130		PAGE 15			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
WJS	22.49	22.51	22.54	22.56	22.58	22.60	22.63	22.65	22.6
	73.73	73.87	73.94	74.01	74.09	74.16	74.24	74.31	74.2
WJU	22.67	22.70	22.72	22.74	22.77	22.79	22.81	22.84	23.3
	74.34	74.46	74.54	74.62	74.69	74.77	74.85	74.92	76.3
WJR	22.86	22.89	22.91	22.93	22.96	22.98	23.00	23.03	24.0
	75.00	75.09	75.16	75.23	75.31	75.38	75.47	75.55	78.6
WJW	23.05	23.08	23.10	23.13	23.15	23.17	23.20	23.22	24.7
	75.63	75.71	75.79	75.87	75.95	76.03	76.11	76.20	81.0
WJO	23.25	23.27	23.30	23.33	23.35	23.38	23.40	23.43	25.5
	76.29	76.36	76.44	76.53	76.61	76.69	76.78	76.86	83.5
WJK	23.45	23.48	23.51	23.53	23.56	23.58	23.61	23.64	26.3
	76.95	77.03	77.12	77.20	77.29	77.38	77.46	77.55	86.2
WJG	23.66	23.69	23.72	23.75	23.77	23.80	23.83	23.85	27.2
	77.64	77.73	77.82	77.90	77.99	78.08	78.17	78.26	89.1
WJO	23.86	23.91	23.94	23.97	23.99	24.02	24.05	24.08	28.1
	78.35	78.44	78.54	78.63	78.72	78.81	78.91	79.00	92.2
WKS	24.11	24.14	24.16	24.19	24.22	24.25	24.28	24.31	29.1
	79.09	79.19	79.28	79.38	79.47	79.57	79.66	79.76	95.5
WKU	24.34	24.37	24.40	24.43	24.46	24.49	24.52	24.55	30.2
	79.86	79.96	80.05	80.15	80.25	80.35	80.45	80.55	99.0
WKR	24.58	24.61	24.64	24.68	24.71	24.74	24.77	24.80	31.3
	80.65	80.75	80.86	80.96	81.06	81.16	81.27	81.37	102.8
WKW	24.83	24.87	24.90	24.93	24.96	25.00	25.03	25.06	32.6
	81.43	81.58	81.69	81.79	81.90	82.01	82.12	82.23	107.0
WKO	25.10	25.13	25.16	25.20	25.23	25.26	25.30	25.33	34.0
	82.33	82.44	82.55	82.67	82.78	82.89	83.00	83.11	111.4
WKK	25.37	25.40	25.44	25.47	25.51	25.54	25.58	25.62	35.5
	83.23	83.34	83.48	83.57	83.69	83.81	83.92	84.04	116.3
WKG	25.55	25.59	25.73	25.76	25.80	25.84	25.87	25.91	37.1
	84.16	84.29	84.40	84.52	84.64	84.77	84.89	85.01	121.6
WKO	25.35	25.93	25.03	26.07	26.10	26.14	26.18	26.22	38.8
	85.14	85.26	85.39	85.52	85.64	85.77	85.90	86.03	127.4

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 16			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	D	
WGS	26.26	26.30	26.34	26.38	26.42	26.46	26.51	26.55	40.8
	86.16	86.29	86.42	86.56	86.69	86.83	86.96	87.10	133.8
WGU	26.53	26.63	26.67	26.72	26.76	26.80	26.85	26.89	42.9
	87.23	87.37	87.51	87.65	87.79	87.93	88.08	88.22	140.9
WGR	26.93	26.98	27.02	27.07	27.11	27.16	27.20	27.25	45.3
	88.37	88.51	88.66	88.81	88.95	89.10	89.25	89.41	148.8
WGW	27.30	27.34	27.39	27.44	27.49	27.54	27.58	27.63	48.0
	89.56	89.71	89.87	90.02	90.16	90.34	90.50	90.66	157.5
WGO	27.68	27.73	27.78	27.83	27.88	27.94	27.99	28.04	51.0
	90.82	90.99	91.15	91.32	91.49	91.65	91.82	92.00	167.4
WGK	28.09	28.15	28.20	28.25	28.31	28.36	28.42	28.47	54.4
	92.17	92.34	92.52	92.70	92.87	93.05	93.24	93.42	178.6
WGG	28.53	28.59	28.64	28.70	28.76	28.82	28.88	28.94	58.3
	93.60	93.79	93.98	94.17	94.36	94.55	94.75	94.94	191.4
WGD	29.00	29.06	29.12	29.18	29.25	29.31	29.37	29.44	62.8
	95.14	95.34	95.54	95.75	95.95	96.16	96.37	96.59	206.1
WDS	29.50	29.57	29.64	29.70	29.77	29.84	29.91	29.98	68.1
	96.80	97.02	97.23	97.46	97.68	97.90	98.13	98.36	223.3
WDU	30.05	30.12	30.20	30.27	30.34	30.42	30.49	30.57	74.3
	98.60	98.83	99.07	99.31	99.55	99.80	100.05	100.30	243.6
WDR	30.65	30.73	30.81	30.89	30.97	31.05	31.14	31.22	81.7
	100.56	100.81	101.08	101.34	101.61	101.88	102.15	102.43	267.9
WDW	31.31	31.39	31.48	31.57	31.66	31.75	31.85	31.94	90.7
	102.71	103.00	103.29	103.56	103.88	104.18	104.49	104.80	297.6
WDO	32.04	32.14	32.23	32.33	32.44	32.54	32.65	32.75	102.3
	105.11	105.43	105.75	106.09	106.42	106.76	107.11	107.46	335.6
WDK	32.86	32.97	33.08	33.20	33.32	33.44	33.56	33.69	117.6
	107.82	108.18	108.55	108.93	109.32	109.71	110.11	110.52	385.7
WDG	33.81	33.94	34.07	34.21	34.35	34.49	34.63	34.78	138.8
	110.93	111.36	111.79	112.23	112.69	113.15	113.62	114.10	452.6
WDD	34.93	35.08	35.24	35.40	35.57	35.74	35.91	36.09	166.5
	114.60	115.10	115.62	116.15	116.70	117.26	117.83	118.42	546.3

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39130			PAGE 17		AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	O	
OSS	22.36	22.37	22.38	22.39	22.40	22.41	22.43	22.44	11.0
	73.36	73.39	73.43	73.47	73.50	73.54	73.57	73.61	36.1
OSU	22.45	22.46	22.47	22.48	22.49	22.50	22.51	22.53	11.2
	73.65	73.69	73.72	73.76	73.79	73.83	73.87	73.90	36.6
OSR	22.54	22.55	22.56	22.57	22.58	22.59	22.60	22.62	11.3
	73.94	73.98	74.01	74.05	74.09	74.13	74.16	74.20	37.1
OSW	22.63	22.64	22.65	22.66	22.67	22.68	22.70	22.71	11.5
	74.24	74.28	74.31	74.35	74.39	74.43	74.46	74.50	37.7
OSO	22.72	22.73	22.74	22.75	22.77	22.78	22.79	22.80	11.6
	74.54	74.58	74.62	74.65	74.69	74.73	74.77	74.81	38.2
OSK	22.81	22.82	22.84	22.85	22.86	22.87	22.88	22.90	11.8
	74.85	74.89	74.92	74.96	75.00	75.04	75.08	75.12	38.8
OSG	22.91	22.92	22.93	22.94	22.96	22.97	22.98	22.99	12.0
	75.16	75.19	75.23	75.27	75.31	75.35	75.39	75.43	39.3
OSO	23.00	23.02	23.03	23.04	23.05	23.06	23.08	23.09	12.2
	75.47	75.51	75.55	75.59	75.63	75.67	75.71	75.75	39.9
OJC	23.10	23.11	23.13	23.14	23.15	23.16	23.17	23.19	12.4
	75.78	75.82	75.87	75.91	75.95	75.99	76.03	76.07	40.5
OJO	23.20	23.21	23.22	23.24	23.25	23.26	23.27	23.29	12.5
	76.11	76.16	76.20	76.24	76.28	76.32	76.36	76.40	41.2
OJR	23.30	23.31	23.33	23.34	23.35	23.36	23.38	23.39	12.7
	76.44	76.48	76.53	76.57	76.61	76.65	76.69	76.74	41.8
OJW	23.40	23.42	23.43	23.44	23.45	23.47	23.48	23.49	12.9
	76.78	76.82	76.86	76.91	76.95	76.99	77.03	77.09	42.5
OJO	23.51	23.52	23.53	23.55	23.56	23.57	23.58	23.60	13.2
	77.12	77.16	77.20	77.25	77.29	77.33	77.38	77.42	43.1
OJK	23.61	23.62	23.64	23.65	23.66	23.68	23.69	23.70	13.4
	77.46	77.51	77.55	77.60	77.64	77.68	77.73	77.77	43.9
OJG	23.72	23.73	23.75	23.76	23.77	23.79	23.80	23.81	13.6
	77.82	77.86	77.90	77.95	77.99	78.04	78.08	78.13	44.6
OJO	23.83	23.84	23.85	23.87	23.88	23.90	23.91	23.92	13.8
	78.17	78.22	78.26	78.31	78.35	78.40	78.44	78.49	45.3

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 18			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	C	
DRS	23.94	23.95	23.97	23.98	23.99	24.01	24.02	24.04	14.1
	78.54	78.58	78.63	78.67	78.72	78.77	78.81	78.86	46.1
DRU	24.05	24.06	24.08	24.09	24.11	24.12	24.14	24.15	14.3
	78.91	78.95	79.00	79.05	79.09	79.14	79.19	79.23	46.9
DRR	24.15	24.16	24.18	24.21	24.22	24.24	24.25	24.27	14.6
	79.25	79.33	79.38	79.42	79.47	79.52	79.57	79.62	47.8
DRW	24.28	24.30	24.31	24.33	24.34	24.36	24.37	24.39	14.8
	79.55	79.71	79.75	79.81	79.86	79.91	79.96	80.00	48.7
DRD	24.40	24.42	24.43	24.45	24.46	24.48	24.49	24.51	15.1
	80.05	80.10	80.15	80.20	80.25	80.30	80.35	80.40	49.6
DRK	24.52	24.54	24.55	24.57	24.58	24.60	24.61	24.63	15.4
	80.45	80.50	80.55	80.60	80.65	80.70	80.75	80.80	50.5
DRG	24.64	24.66	24.68	24.69	24.71	24.72	24.74	24.75	15.7
	80.89	80.91	80.96	81.01	81.06	81.11	81.16	81.22	51.5
DRD	24.77	24.79	24.80	24.82	24.83	24.85	24.87	24.89	16.0
	81.27	81.32	81.37	81.42	81.48	81.53	81.58	81.64	52.5
DWS	24.90	24.91	24.93	24.95	24.96	24.98	25.00	25.01	16.3
	81.69	81.74	81.79	81.85	81.90	81.96	82.01	82.06	53.5
DWU	25.03	25.05	25.06	25.08	25.10	25.11	25.13	25.15	16.7
	82.12	82.17	82.23	82.28	82.33	82.39	82.44	82.50	54.6
DWR	25.16	25.18	25.20	25.21	25.23	25.25	25.26	25.28	17.0
	82.55	82.61	82.67	82.72	82.78	82.83	82.89	82.95	55.8
DWW	25.30	25.32	25.33	25.35	25.37	25.39	25.40	25.42	17.4
	83.00	83.06	83.11	83.17	83.23	83.29	83.34	83.40	57.0
DWD	25.44	25.46	25.47	25.49	25.51	25.53	25.54	25.56	17.7
	83.46	83.52	83.57	83.63	83.69	83.75	83.81	83.87	58.2
DWK	25.58	25.60	25.62	25.63	25.65	25.67	25.69	25.71	18.1
	83.92	83.98	84.04	84.10	84.16	84.22	84.28	84.34	59.5
DWG	25.73	25.74	25.75	25.78	25.80	25.82	25.84	25.86	18.6
	84.40	84.46	84.52	84.58	84.64	84.71	84.77	84.83	60.9
DWD	25.87	25.89	25.91	25.93	25.95	25.97	25.99	26.01	19.0
	84.89	84.95	85.01	85.08	85.14	85.20	85.26	85.33	62.3

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 19			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	C	
CCS	26.03	26.05	26.07	26.08	26.10	26.12	26.14	26.16	19.4
	85.33	85.45	85.52	85.58	85.64	85.71	85.77	85.84	63.8
CCU	26.18	26.20	26.22	26.24	26.26	26.28	26.30	26.32	19.9
	85.90	85.96	86.03	86.09	86.16	86.23	86.29	86.36	65.4
CCR	26.34	26.36	26.38	26.40	26.42	26.44	26.46	26.48	20.4
	86.42	86.49	86.55	86.62	86.69	86.76	86.83	86.89	67.0
CCW	26.51	26.53	26.55	26.57	26.59	26.61	26.63	26.65	21.0
	86.96	87.03	87.10	87.17	87.23	87.30	87.37	87.44	68.7
CCC	26.67	26.69	26.72	26.74	26.76	26.78	26.80	26.82	21.5
	87.51	87.58	87.65	87.72	87.79	87.86	87.93	88.01	70.6
CCK	26.85	26.87	26.89	26.91	26.93	26.96	26.98	27.00	22.1
	88.03	88.15	88.22	88.29	88.37	88.44	88.51	88.58	72.5
CCG	27.02	27.05	27.07	27.09	27.11	27.14	27.16	27.18	22.7
	88.66	88.73	88.81	88.88	88.95	89.03	89.10	89.18	74.5
CCO	27.20	27.23	27.25	27.27	27.30	27.32	27.34	27.37	23.4
	89.25	89.33	89.41	89.48	89.56	89.64	89.71	89.79	76.6
CKS	27.39	27.42	27.44	27.46	27.49	27.51	27.54	27.56	24.0
	89.87	89.95	90.02	90.10	90.18	90.26	90.34	90.42	78.9
CKU	27.53	27.61	27.63	27.66	27.68	27.71	27.73	27.76	24.8
	90.50	90.59	90.66	90.74	90.82	90.91	90.99	91.07	81.3
CKR	27.78	27.81	27.83	27.86	27.88	27.91	27.94	27.96	25.6
	91.15	91.24	91.32	91.40	91.49	91.57	91.65	91.74	83.9
CKW	27.99	28.01	28.04	28.07	28.09	28.12	28.15	28.17	26.4
	91.82	91.91	92.00	92.08	92.17	92.26	92.34	92.43	86.6
CKC	28.20	28.23	28.25	28.28	28.31	28.34	28.36	28.39	27.3
	92.52	92.61	92.70	92.79	92.87	92.96	93.05	93.15	89.5
CKK	28.42	28.45	28.47	28.50	28.53	28.56	28.59	28.62	28.2
	93.24	93.33	93.42	93.51	93.60	93.70	93.79	93.88	92.6
CKG	28.64	28.67	28.70	28.73	28.76	28.79	28.82	28.85	29.2
	93.98	94.07	94.17	94.26	94.36	94.46	94.55	94.65	95.9
CKO	28.88	28.91	28.94	28.97	29.00	29.03	29.06	29.09	30.3
	94.75	94.85	94.94	95.04	95.14	95.24	95.34	95.44	99.4

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 20 AVERAGE RESOLUTION

ALTITUDE: KILOMETERS
KILOFEET

METERS
FEET

	S	U	R	W	D	K	G	J	
DGS	29.12	29.15	29.18	29.22	29.25	29.28	29.31	29.34	31.5
	95.54	95.65	95.75	95.85	95.95	96.06	96.16	96.27	103.3
DGU	29.37	29.41	29.44	29.47	29.50	29.54	29.57	29.60	32.7
	96.37	96.48	96.59	96.69	96.80	96.91	97.02	97.12	107.4
DGR	29.64	29.67	29.70	29.74	29.77	29.81	29.84	29.88	34.1
	97.23	97.34	97.46	97.57	97.68	97.79	97.90	98.02	111.9
DGW	29.91	29.95	29.98	30.02	30.05	30.09	30.12	30.16	35.6
	98.13	98.25	98.36	98.48	98.60	98.71	98.83	98.95	116.8
DGD	30.20	30.23	30.27	30.31	30.34	30.38	30.42	30.46	37.2
	99.07	99.18	99.31	99.43	99.55	99.68	99.80	99.92	122.1
DGK	30.49	30.53	30.57	30.61	30.65	30.69	30.73	30.77	39.0
	100.05	100.17	100.30	100.43	100.56	100.68	100.81	100.94	127.9
DGG	30.81	30.85	30.89	30.93	30.97	31.01	31.05	31.09	40.9
	101.03	101.21	101.34	101.47	101.61	101.74	101.88	102.02	134.3
DGO	31.14	31.18	31.22	31.26	31.31	31.35	31.39	31.44	43.1
	102.15	102.29	102.43	102.57	102.71	102.86	103.00	103.14	141.4
DJS	31.48	31.53	31.57	31.62	31.66	31.71	31.75	31.80	45.5
	103.23	103.43	103.58	103.73	103.88	104.03	104.18	104.33	149.2
DJU	31.85	31.89	31.94	31.99	32.04	32.09	32.14	32.18	48.2
	104.49	104.64	104.80	104.95	105.11	105.27	105.43	105.59	158.0
DJR	32.23	32.28	32.33	32.39	32.44	32.49	32.54	32.59	51.3
	105.76	105.92	106.09	106.25	106.42	106.59	106.76	106.93	168.3
DJW	32.65	32.70	32.75	32.81	32.86	32.92	32.97	33.03	54.9
	107.11	107.28	107.45	107.64	107.82	108.00	108.18	108.37	180.1
DJD	33.09	33.14	33.20	33.26	33.32	33.38	33.44	33.50	59.0
	108.56	108.74	108.93	109.12	109.32	109.51	109.71	109.91	193.5
DJK	33.56	33.62	33.69	33.75	33.81	33.88	33.94	34.01	63.7
	110.11	110.31	110.52	110.73	110.93	111.15	111.36	111.57	209.1
DJG	34.07	34.14	34.21	34.28	34.35	34.42	34.49	34.56	69.3
	111.79	112.01	112.23	112.46	112.69	112.92	113.15	113.38	227.2
DJO	34.63	34.70	34.78	34.85	34.93	35.01	35.08	35.16	75.8
	113.62	113.86	114.10	114.35	114.60	114.85	115.10	115.36	248.7

CONFIDENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 21

									AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
[illegible]	26.33	26.34	26.35	26.97	26.98	26.99	27.00	27.01	11.1
	86.37	86.40	86.44	86.47	86.51	86.55	86.58	86.62	36.5
[illegible]	27.02	27.03	27.05	27.06	27.07	27.08	27.09	27.10	11.3
	86.65	86.69	86.73	86.77	86.81	86.84	86.88	86.92	37.0
[illegible]	27.11	27.12	27.14	27.15	27.16	27.17	27.18	27.19	11.4
	86.95	86.99	87.03	87.07	87.10	87.14	87.18	87.22	37.5
[illegible]	27.20	27.22	27.23	27.24	27.25	27.26	27.27	27.29	11.6
	87.25	87.29	87.33	87.37	87.41	87.44	87.48	87.52	38.1
[illegible]	27.30	27.31	27.32	27.33	27.34	27.36	27.37	27.38	11.8
	87.59	87.60	87.64	87.67	87.71	87.75	87.79	87.83	38.6
[illegible]	27.39	27.40	27.42	27.43	27.44	27.45	27.46	27.48	11.9
	87.87	87.91	87.95	87.99	88.02	88.06	88.10	88.14	39.2
[illegible]	27.49	27.50	27.51	27.52	27.54	27.55	27.56	27.57	12.1
	88.18	88.22	88.26	88.30	88.34	88.38	88.42	88.46	39.8
[illegible]	27.59	27.60	27.61	27.62	27.63	27.65	27.66	27.67	12.3
	88.50	88.54	88.58	88.62	88.66	88.70	88.74	88.78	40.4
[illegible]	27.68	27.70	27.71	27.72	27.73	27.75	27.76	27.77	12.5
	88.82	88.87	88.91	88.95	88.99	89.03	89.07	89.11	41.0
[illegible]	27.79	27.80	27.81	27.82	27.83	27.85	27.86	27.87	12.7
	89.15	89.19	89.24	89.28	89.32	89.36	89.40	89.44	41.6
[illegible]	27.89	27.90	27.91	27.92	27.94	27.95	27.96	27.98	12.9
	89.49	89.53	89.57	89.61	89.65	89.70	89.74	89.78	42.3
[illegible]	27.99	28.00	28.01	28.03	28.04	28.05	28.07	28.08	13.1
	89.82	89.87	89.91	89.95	90.00	90.04	90.08	90.13	43.0
[illegible]	28.09	28.11	28.12	28.13	28.15	28.16	28.17	28.19	13.3
	90.17	90.21	90.26	90.30	90.34	90.39	90.43	90.47	43.7
[illegible]	28.20	28.21	28.23	28.24	28.25	28.27	28.28	28.29	13.5
	90.52	90.56	90.61	90.65	90.70	90.74	90.79	90.83	44.4
[illegible]	28.31	28.32	28.34	28.35	28.36	28.38	28.39	28.40	13.8
	90.87	90.92	90.96	91.01	91.05	91.10	91.15	91.19	45.2
[illegible]	28.42	28.43	28.45	28.46	28.47	28.49	28.50	28.52	14.0
	91.24	91.28	91.33	91.37	91.42	91.47	91.51	91.56	45.9

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 22 AVERAGE RESOLUTION

ALTITUDE: KILOMETERS
KILOFEET

METERS
FEET

	S	U	R	W	D	K	G	O	
KRS	28.53	28.54	28.55	28.57	28.59	28.60	28.62	28.63	14.2
	93.60	93.65	93.70	93.74	93.79	93.84	93.88	93.93	46.7
KRU	28.64	28.66	28.67	28.69	28.70	28.72	28.73	28.75	14.5
	93.98	94.03	94.07	94.12	94.17	94.22	94.26	94.31	47.6
KRR	28.76	28.78	28.79	28.80	28.82	28.83	28.85	28.86	14.8
	94.36	94.41	94.45	94.50	94.55	94.60	94.65	94.70	48.4
KRW	28.88	28.89	28.91	28.92	28.94	28.95	28.97	28.98	15.0
	94.75	94.80	94.85	94.89	94.94	94.99	95.04	95.09	49.3
KRD	29.00	29.01	29.03	29.05	29.06	29.08	29.09	29.11	15.3
	95.14	95.19	95.24	95.29	95.34	95.39	95.44	95.49	50.2
KRK	29.12	29.14	29.15	29.17	29.18	29.20	29.22	29.23	15.6
	95.54	95.60	95.65	95.70	95.75	95.80	95.85	95.90	51.2
KRG	29.25	29.26	29.28	29.29	29.31	29.33	29.34	29.36	15.9
	95.95	96.01	96.05	96.11	96.16	96.22	96.27	96.32	52.2
KRO	29.37	29.39	29.41	29.42	29.44	29.46	29.47	29.49	16.2
	96.37	96.43	96.48	96.53	96.59	96.64	96.69	96.75	53.2
KWS	29.50	29.52	29.54	29.55	29.57	29.59	29.60	29.62	16.6
	96.80	96.85	96.91	96.96	97.02	97.07	97.12	97.18	54.3
KWU	29.64	29.65	29.67	29.69	29.70	29.72	29.74	29.76	16.9
	97.23	97.29	97.34	97.40	97.46	97.51	97.57	97.62	55.4
KWR	29.77	29.79	29.81	29.82	29.84	29.86	29.88	29.89	17.3
	97.58	97.73	97.79	97.85	97.90	97.96	98.02	98.08	56.6
KWW	29.91	29.93	29.95	29.96	29.98	30.00	30.02	30.03	17.6
	98.13	98.19	98.25	98.30	98.36	98.42	98.48	98.54	57.8
KWO	30.05	30.07	30.09	30.11	30.12	30.14	30.16	30.18	18.0
	98.60	98.65	98.71	98.77	98.83	98.89	98.95	99.01	59.1
KWK	30.20	30.21	30.23	30.25	30.27	30.29	30.31	30.33	18.4
	99.07	99.13	99.19	99.25	99.31	99.37	99.43	99.49	60.4
KWG	30.34	30.36	30.38	30.40	30.42	30.44	30.46	30.48	18.8
	99.55	99.61	99.68	99.74	99.80	99.86	99.92	99.99	61.8
KWO	30.43	30.51	30.53	30.55	30.57	30.59	30.61	30.63	19.3
	100.05	100.11	100.17	100.24	100.30	100.36	100.43	100.49	63.3

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 23			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	M	D	K	G	O	
KJS	30.65	30.67	30.69	30.71	30.73	30.75	30.77	30.79	19.8
	100.56	100.62	100.68	100.75	100.81	100.88	100.94	101.01	64.8
KJU	30.91	30.93	30.95	30.87	30.89	30.91	30.93	30.95	20.2
	101.08	101.14	101.21	101.27	101.34	101.41	101.47	101.54	66.4
KJR	30.97	30.99	31.01	31.03	31.05	31.07	31.09	31.12	20.8
	101.61	101.68	101.74	101.81	101.88	101.95	102.02	102.08	68.1
KJW	31.14	31.16	31.18	31.20	31.22	31.24	31.26	31.29	21.3
	102.15	102.22	102.29	102.36	102.43	102.50	102.57	102.64	69.9
KJD	31.31	31.33	31.35	31.37	31.39	31.42	31.44	31.46	21.9
	102.71	102.78	102.85	102.93	103.00	103.07	103.14	103.22	71.7
KJK	31.48	31.50	31.53	31.55	31.57	31.59	31.62	31.64	22.5
	103.29	103.36	103.43	103.51	103.58	103.66	103.73	103.80	73.7
KJG	31.66	31.69	31.71	31.73	31.75	31.78	31.80	31.82	23.1
	103.88	103.95	104.03	104.10	104.18	104.26	104.33	104.41	75.8
KJO	31.85	31.87	31.89	31.92	31.94	31.97	31.99	32.01	23.8
	104.49	104.56	104.64	104.72	104.80	104.87	104.95	105.03	78.0
KKS	32.04	32.06	32.09	32.11	32.14	32.16	32.18	32.21	24.5
	105.11	105.19	105.27	105.35	105.43	105.51	105.59	105.67	80.4
KKU	32.23	32.26	32.28	32.31	32.33	32.36	32.39	32.41	25.3
	105.76	105.84	105.92	106.00	106.09	106.17	106.25	106.34	83.0
KKR	32.44	32.46	32.49	32.51	32.54	32.57	32.59	32.62	26.1
	106.42	106.51	106.59	106.68	106.76	106.85	106.93	107.02	85.7
KKW	32.65	32.67	32.70	32.73	32.75	32.78	32.81	32.84	27.0
	107.11	107.20	107.28	107.37	107.46	107.55	107.64	107.73	88.7
KKD	32.86	32.89	32.92	32.95	32.97	33.00	33.03	33.06	28.0
	107.92	107.91	108.00	106.09	108.18	108.28	108.37	108.46	91.8
KKK	33.09	33.12	33.14	33.17	33.20	33.23	33.26	33.29	29.0
	108.56	108.65	108.74	106.84	108.93	109.03	109.12	109.22	95.2
KKG	33.32	33.35	33.38	33.41	33.44	33.47	33.50	33.53	30.1
	109.32	109.42	109.51	109.61	109.71	109.81	109.91	110.01	98.8
KKO	33.56	33.59	33.62	33.65	33.69	33.72	33.75	33.78	31.3
	110.11	110.21	110.31	110.42	110.52	110.62	110.73	110.83	102.7

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 24

ALTITUDE: KILOMETERS
KILOFEET

	S	U	R	W	D	K	G	C	AVERAGE RESOLUTION METERS FEET
KGS	33.81	33.84	33.88	33.91	33.94	33.97	34.01	34.04	32.6
	110.93	111.04	111.15	111.25	111.36	111.47	111.57	111.68	106.9
KGU	34.07	34.11	34.14	34.18	34.21	34.24	34.28	34.31	34.0
	111.79	111.90	112.01	112.12	112.23	112.35	112.46	112.57	111.5
KGR	34.35	34.38	34.42	34.45	34.49	34.52	34.56	34.60	35.5
	112.69	112.80	112.92	113.03	113.15	113.26	113.38	113.50	116.4
KGW	34.63	34.67	34.70	34.74	34.78	34.82	34.85	34.89	37.1
	113.62	113.74	113.86	113.98	114.10	114.23	114.35	114.47	121.8
KGD	34.93	34.97	35.01	35.04	35.08	35.12	35.16	35.20	38.9
	114.60	114.72	114.85	114.98	115.10	115.23	115.36	115.49	127.7
KGK	35.24	35.28	35.32	35.36	35.40	35.44	35.49	35.53	40.9
	115.62	115.75	115.89	116.02	116.15	116.29	116.42	116.56	134.1
KGG	35.57	35.61	35.65	35.70	35.74	35.78	35.83	35.87	43.0
	116.70	116.84	116.98	117.12	117.26	117.40	117.54	117.69	141.2
KGO	35.91	35.96	36.00	36.05	36.09	36.14	36.19	36.23	45.4
	117.83	117.98	118.12	118.27	118.42	118.57	118.72	118.87	149.1
KOS	36.28	36.33	36.37	36.42	36.47	36.52	36.57	36.62	48.1
	119.03	119.18	119.34	119.49	119.65	119.81	119.97	120.13	157.9
KOU	36.57	36.72	36.77	36.82	36.87	36.92	36.97	37.02	51.1
	120.30	120.46	120.63	120.79	120.96	121.13	121.30	121.47	167.7
KOR	37.08	37.13	37.18	37.24	37.29	37.35	37.40	37.46	54.5
	121.64	121.82	121.99	122.17	122.35	122.53	122.71	122.89	178.8
KOW	37.51	37.57	37.63	37.69	37.74	37.80	37.86	37.92	58.3
	123.08	123.26	123.45	123.64	123.83	124.03	124.22	124.42	191.3
KOD	37.98	38.04	38.11	38.17	38.23	38.29	38.36	38.42	62.7
	124.62	124.82	125.02	125.22	125.43	125.64	125.84	126.06	205.7
KOK	38.49	38.55	38.62	38.69	38.75	38.82	38.89	38.96	67.8
	126.27	126.49	126.70	126.92	127.15	127.37	127.60	127.83	222.4
KOG	39.03	39.10	39.18	39.25	39.32	39.40	39.47	39.55	73.7
	128.06	128.29	128.53	128.77	129.01	129.25	129.50	129.75	241.8
KOO	39.63	39.70	39.78	39.86	39.94	40.02	40.11	40.19	80.7
	130.00	130.26	130.52	130.78	131.04	131.31	131.58	131.86	264.9

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 25			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	J	
GSS	31.57	31.58	31.59	31.61	31.62	31.63	31.64	31.65	11.3
	103.58	103.62	103.66	103.69	103.73	103.77	103.80	103.84	37.1
GSU	31.66	31.67	31.68	31.70	31.71	31.72	31.73	31.74	11.5
	103.88	103.92	103.95	103.99	104.03	104.07	104.10	104.14	37.7
GSR	31.75	31.77	31.78	31.79	31.80	31.81	31.82	31.84	11.6
	104.13	104.22	104.26	104.29	104.33	104.37	104.41	104.45	38.2
GSW	31.85	31.86	31.87	31.88	31.89	31.91	31.92	31.93	11.8
	104.49	104.52	104.56	104.60	104.64	104.68	104.72	104.76	38.7
GSD	31.94	31.95	31.97	31.98	31.99	32.00	32.01	32.03	12.0
	104.80	104.84	104.87	104.91	104.95	104.99	105.03	105.07	39.3
GSK	32.04	32.05	32.06	32.07	32.09	32.10	32.11	32.12	12.2
	105.11	105.15	105.19	105.23	105.27	105.31	105.35	105.39	39.9
GSG	32.14	32.15	32.16	32.17	32.18	32.20	32.21	32.22	12.4
	105.43	105.47	105.51	105.55	105.59	105.63	105.67	105.71	40.5
GSO	32.23	32.25	32.26	32.27	32.28	32.30	32.31	32.32	12.6
	105.76	105.80	105.84	105.88	105.92	105.96	106.00	106.04	41.2
GJS	32.33	32.35	32.36	32.37	32.39	32.40	32.41	32.42	12.8
	106.09	106.13	106.17	106.21	106.25	106.29	106.34	106.38	41.9
GJU	32.44	32.45	32.46	32.48	32.49	32.50	32.51	32.53	13.0
	106.42	106.46	106.51	106.55	106.59	106.63	106.68	106.72	42.6
GJR	32.54	32.55	32.57	32.58	32.59	32.61	32.62	32.63	13.2
	106.76	106.80	106.85	106.89	106.93	106.98	107.02	107.06	43.3
GJW	32.65	32.66	32.67	32.69	32.70	32.71	32.73	32.74	13.4
	107.11	107.15	107.20	107.24	107.28	107.33	107.37	107.42	44.0
GJD	32.75	32.77	32.78	32.79	32.81	32.82	32.84	32.85	13.6
	107.46	107.50	107.55	107.59	107.64	107.68	107.73	107.77	44.8
GJK	32.86	32.88	32.89	32.90	32.92	32.93	32.95	32.96	13.9
	107.82	107.86	107.91	107.95	108.00	108.05	108.09	108.14	45.6
GJG	32.97	32.99	33.00	33.02	33.03	33.04	33.06	33.07	14.1
	108.18	108.23	108.23	108.32	108.37	108.41	108.46	108.51	46.4
GJO	33.09	33.10	33.12	33.13	33.14	33.16	33.17	33.19	14.4
	108.56	108.60	108.65	108.70	108.74	108.79	108.84	108.89	47.2

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 26			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	J	
GRS	33.20	33.22	33.23	33.25	33.26	33.28	33.29	33.31	14.7
	108.93	108.98	109.03	109.08	109.12	109.17	109.22	109.27	48.1
GRU	33.32	33.34	33.35	33.36	33.38	33.39	33.41	33.42	14.9
	109.32	109.37	109.42	109.46	109.51	109.56	109.61	109.66	49.0
GRR	33.44	33.45	33.47	33.49	33.50	33.52	33.53	33.55	15.2
	109.71	109.76	109.81	109.86	109.91	109.96	110.01	110.06	49.9
GRW	33.56	33.58	33.59	33.61	33.62	33.64	33.65	33.67	15.5
	110.11	110.16	110.21	110.26	110.31	110.36	110.42	110.47	50.9
GRD	33.69	33.70	33.72	33.73	33.75	33.77	33.78	33.80	15.8
	110.52	110.57	110.62	110.67	110.73	110.78	110.83	110.88	51.9
GRK	33.81	33.83	33.84	33.86	33.88	33.89	33.91	33.93	16.1
	110.93	110.99	111.04	111.09	111.15	111.20	111.25	111.31	53.0
GRG	33.94	33.96	33.97	33.99	34.01	34.02	34.04	34.06	16.5
	111.36	111.41	111.47	111.52	111.57	111.63	111.68	111.74	54.1
GRO	34.07	34.09	34.11	34.12	34.14	34.16	34.18	34.19	16.8
	111.79	111.85	111.90	111.96	112.01	112.07	112.12	112.18	55.2
GWS	34.21	34.23	34.24	34.26	34.28	34.29	34.31	34.33	17.2
	112.23	112.29	112.35	112.40	112.46	112.52	112.57	112.63	56.4
GWU	34.35	34.36	34.38	34.40	34.42	34.43	34.45	34.47	17.6
	112.59	112.74	112.80	112.86	112.92	112.97	113.03	113.09	57.6
GWR	34.48	34.51	34.52	34.54	34.56	34.58	34.60	34.61	18.0
	113.15	113.21	113.25	113.32	113.38	113.44	113.50	113.56	58.9
GWW	34.63	34.65	34.67	34.69	34.70	34.72	34.74	34.76	18.4
	113.62	113.68	113.74	113.80	113.86	113.92	113.98	114.04	60.3
GWD	34.78	34.80	34.82	34.83	34.85	34.87	34.89	34.91	18.8
	114.10	114.16	114.23	114.29	114.35	114.41	114.47	114.53	61.7
GWK	34.93	34.95	34.97	34.99	35.01	35.03	35.04	35.06	19.2
	114.60	114.66	114.72	114.79	114.85	114.91	114.98	115.04	63.2
GWG	35.08	35.10	35.12	35.14	35.16	35.18	35.20	35.22	19.7
	115.10	115.17	115.23	115.30	115.36	115.43	115.49	115.56	64.7
GWO	35.24	35.26	35.28	35.30	35.32	35.34	35.36	35.38	20.2
	115.62	115.69	115.75	115.82	115.89	115.95	116.02	116.09	66.3

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 27			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	D	
GDS	35.40	35.42	35.44	35.47	35.49	35.51	35.53	35.55	20.7
	116.15	116.22	116.29	116.36	116.42	116.49	116.56	116.63	68.0
GDU	35.57	35.59	35.61	35.63	35.65	35.68	35.70	35.72	21.3
	116.70	116.77	116.84	116.91	116.98	117.05	117.12	117.19	69.8
GDR	35.74	35.76	35.78	35.80	35.83	35.85	35.87	35.89	21.8
	117.26	117.33	117.40	117.47	117.54	117.61	117.69	117.76	71.7
GDW	35.91	35.94	35.96	35.98	36.00	36.03	36.05	36.07	22.4
	117.83	117.90	117.96	118.05	118.12	118.20	118.27	118.35	73.6
GDD	36.09	36.12	36.14	36.16	36.19	36.21	36.23	36.26	23.1
	118.42	118.50	118.57	118.65	118.72	118.80	118.87	118.95	75.7
GDK	36.28	36.30	36.33	36.35	36.37	36.40	36.42	36.45	23.7
	119.03	119.11	119.19	119.26	119.34	119.42	119.49	119.57	77.9
GDG	36.47	36.49	36.52	36.54	36.57	36.59	36.62	36.64	24.5
	119.65	119.73	119.81	119.89	119.97	120.05	120.13	120.21	80.2
GDO	36.67	36.69	36.72	36.74	36.77	36.79	36.82	36.84	25.2
	120.30	120.38	120.45	120.54	120.62	120.71	120.79	120.87	82.7
GKS	36.87	36.89	36.92	36.95	36.97	37.00	37.02	37.05	25.0
	120.95	121.04	121.12	121.21	121.30	121.38	121.47	121.56	85.3
GKU	37.08	37.10	37.13	37.16	37.18	37.21	37.24	37.26	26.8
	121.64	121.73	121.82	121.90	121.99	122.08	122.17	122.26	88.1
GKR	37.29	37.32	37.35	37.37	37.40	37.43	37.46	37.49	27.8
	122.35	122.44	122.53	122.62	122.71	122.80	122.89	122.99	91.0
GKW	37.51	37.54	37.57	37.60	37.63	37.66	37.69	37.72	28.7
	123.08	123.17	123.26	123.36	123.45	123.55	123.64	123.74	94.2
GKD	37.74	37.77	37.80	37.83	37.86	37.89	37.92	37.95	29.7
	123.53	123.63	124.03	124.12	124.22	124.32	124.42	124.52	97.6
GKK	37.98	38.01	38.04	38.07	38.11	38.14	38.17	38.20	30.8
	124.62	124.72	124.82	124.92	125.02	125.12	125.22	125.32	101.2
GKG	38.23	38.26	38.29	38.33	38.36	38.39	38.42	38.45	32.0
	125.43	125.53	125.64	125.74	125.84	125.95	126.06	126.16	105.1
GKO	38.43	38.52	38.55	38.59	38.62	38.65	38.69	38.72	33.3
	126.27	126.38	126.49	126.59	126.70	126.81	126.92	127.03	109.2

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39130			PAGE 28		AVERAGE RESOLUTION
				ALTITUDE KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	D	K	G	O	
GGS	38.75	38.79	38.82	38.86	38.89	38.93	38.96	39.00	34.7
	127.15	127.26	127.37	127.48	127.60	127.71	127.83	127.94	113.7
GGU	39.03	39.07	39.10	39.14	39.18	39.21	39.25	39.29	36.2
	128.05	128.17	128.28	128.41	128.53	128.65	128.77	128.89	118.6
GGR	39.32	39.36	39.40	39.43	39.47	39.51	39.55	39.59	37.8
	129.01	129.13	129.25	129.38	129.50	129.63	129.75	129.88	123.9
GGM	39.63	39.66	39.70	39.74	39.78	39.82	39.86	39.90	39.5
	130.00	130.13	130.25	130.39	130.52	130.65	130.78	130.91	129.7
GGJ	39.94	39.98	40.02	40.07	40.11	40.15	40.19	40.23	41.5
	131.04	131.19	131.31	131.45	131.58	131.72	131.86	132.00	136.0
GGK	40.24	40.32	40.36	40.40	40.45	40.49	40.54	40.58	43.6
	132.14	132.28	132.42	132.56	132.70	132.85	132.99	133.14	142.9
GGG	40.62	40.67	40.71	40.76	40.81	40.85	40.90	40.95	45.9
	133.28	133.43	133.59	133.73	133.88	134.03	134.18	134.34	150.6
GGO	40.99	41.04	41.09	41.14	41.19	41.23	41.28	41.33	48.5
	134.49	134.65	134.81	134.96	135.12	135.28	135.44	135.61	159.1
GJS	41.51	41.45	41.48	41.53	41.59	41.64	41.69	41.74	51.4
	135.77	135.93	136.10	136.27	136.44	136.61	136.78	136.95	168.5
GJU	41.97	41.95	41.98	41.96	42.01	42.07	42.12	42.18	54.6
	137.12	137.30	137.47	137.65	137.83	138.01	138.19	138.38	179.1
GJP	42.23	42.29	42.35	42.41	42.46	42.52	42.58	42.64	58.3
	138.56	138.75	138.94	139.13	139.32	139.51	139.70	139.90	191.1
GJW	42.73	42.76	42.82	42.89	42.95	43.01	43.07	43.14	62.4
	140.19	140.39	140.58	140.78	140.98	141.11	141.32	141.53	204.7
GJJ	43.20	43.27	43.33	43.40	43.47	43.54	43.60	43.67	67.2
	141.74	141.96	142.17	142.39	142.61	142.83	143.06	143.29	220.3
GJK	43.74	43.81	43.88	43.96	44.03	44.10	44.18	44.25	72.7
	143.51	143.75	143.98	144.21	144.45	144.69	144.94	145.18	238.4
GJG	44.33	44.40	44.46	44.56	44.64	44.72	44.80	44.88	79.1
	145.43	145.68	145.94	146.19	146.45	146.71	146.98	147.25	259.6
GJO	44.36	45.05	45.13	45.22	45.30	45.33	45.48	45.57	86.8
	147.52	147.79	148.07	148.35	148.64	148.93	149.22	149.51	284.7

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 29

ALTITUDE: KILOMETERS
KILOFEET

	S	U	R	W	D	K	G	O	AVERAGE RESOLUTION METERS FEET
OSS	35.28	35.29	35.30	35.31	35.32	35.33	35.34	35.35	10.1
	115.75	115.79	115.82	115.85	115.89	115.92	115.95	115.99	33.2
OSU	35.36	35.37	35.38	35.39	35.40	35.41	35.42	35.43	10.2
	116.02	116.05	116.09	116.12	116.15	116.19	116.22	116.25	33.6
OSR	35.44	35.45	35.47	35.48	35.49	35.50	35.51	35.52	10.4
	116.23	116.32	116.35	116.39	116.42	116.46	116.49	116.53	34.0
OSW	35.53	35.54	35.55	35.56	35.57	35.58	35.59	35.60	10.5
	116.56	116.59	116.63	116.66	116.70	116.73	116.77	116.80	34.5
OSO	35.61	35.62	35.63	35.64	35.65	35.66	35.68	35.69	10.6
	116.84	116.87	116.91	116.94	116.98	117.01	117.05	117.08	34.9
OSK	35.70	35.71	35.72	35.73	35.74	35.75	35.76	35.77	10.8
	117.12	117.15	117.19	117.22	117.26	117.29	117.33	117.36	35.4
OSG	35.78	35.79	35.80	35.82	35.83	35.84	35.85	35.86	10.9
	117.40	117.43	117.47	117.51	117.54	117.58	117.61	117.65	35.9
OSO	35.87	35.88	35.89	35.90	35.91	35.93	35.94	35.95	11.1
	117.69	117.72	117.76	117.79	117.83	117.87	117.90	117.94	36.3
OJS	35.96	35.97	35.98	35.99	36.00	36.02	36.03	36.04	11.2
	117.98	118.01	118.05	118.09	118.12	118.16	118.20	118.24	36.8
OJU	36.05	36.06	36.07	36.08	36.09	36.11	36.12	36.13	11.4
	118.27	118.31	118.35	118.38	118.42	118.46	118.50	118.54	37.4
OJR	36.14	36.15	36.16	36.18	36.19	36.20	36.21	36.22	11.5
	118.57	118.61	118.65	118.68	118.72	118.76	118.80	118.84	37.9
OJW	36.23	36.24	36.26	36.27	36.28	36.29	36.30	36.32	11.7
	118.87	118.91	118.95	118.99	119.03	119.07	119.11	119.14	38.4
OJO	36.33	36.34	36.35	36.36	36.37	36.39	36.40	36.41	11.9
	119.18	119.22	119.26	119.30	119.34	119.38	119.42	119.46	39.0
OJK	36.42	36.43	36.45	36.46	36.47	36.48	36.49	36.51	12.1
	119.49	119.53	119.57	119.61	119.65	119.69	119.73	119.77	39.6
OJG	36.52	36.53	36.54	36.56	36.57	36.58	36.59	36.60	12.2
	119.81	119.85	119.89	119.93	119.97	120.01	120.05	120.09	40.2
OJO	36.62	36.63	36.64	36.65	36.67	36.68	36.69	36.70	12.4
	120.13	120.17	120.21	120.25	120.30	120.34	120.38	120.42	40.8

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 30 AVERAGE RESOLUTION

ALTITUDE: KILOMETERS
KILOFEET

METERS
FEET

	S	U	R	W	D	K	G	O	
ORS	36.72	36.73	36.74	36.75	36.77	36.78	36.79	36.80	12.6
	120.46	120.50	120.54	120.58	120.62	120.67	120.71	120.75	41.4
ORU	36.82	36.83	36.84	36.86	36.87	36.89	36.89	36.91	12.8
	120.79	120.83	120.87	120.92	120.96	121.00	121.04	121.09	42.0
ORR	36.92	36.93	36.95	36.96	36.97	36.98	37.00	37.01	13.0
	121.13	121.17	121.21	121.26	121.30	121.34	121.38	121.43	42.7
ORW	37.02	37.04	37.05	37.06	37.08	37.09	37.10	37.12	13.2
	121.47	121.51	121.56	121.60	121.64	121.69	121.73	121.77	43.4
ORO	37.13	37.14	37.16	37.17	37.18	37.20	37.21	37.22	13.4
	121.82	121.86	121.90	121.95	121.99	122.04	122.08	122.13	44.1
ORK	37.24	37.25	37.26	37.28	37.29	37.31	37.32	37.33	13.7
	122.17	122.21	122.25	122.30	122.35	122.39	122.44	122.48	44.8
ORG	37.35	37.36	37.37	37.39	37.40	37.42	37.43	37.44	13.9
	122.53	122.57	122.62	122.66	122.71	122.76	122.80	122.85	45.6
ORD	37.46	37.47	37.49	37.50	37.51	37.53	37.54	37.56	14.1
	122.89	122.94	122.98	123.03	123.08	123.12	123.17	123.22	46.3
OMS	37.57	37.59	37.60	37.61	37.63	37.64	37.66	37.67	14.4
	123.26	123.31	123.36	123.41	123.45	123.50	123.55	123.59	47.1
OMU	37.69	37.70	37.72	37.73	37.74	37.76	37.77	37.79	14.6
	123.64	123.69	123.74	123.79	123.83	123.88	123.93	123.98	48.0
OMR	37.80	37.82	37.83	37.85	37.86	37.88	37.89	37.91	14.9
	124.03	124.08	124.12	124.17	124.22	124.27	124.32	124.37	48.8
OMW	37.92	37.94	37.95	37.97	37.98	38.00	38.01	38.03	15.2
	124.42	124.47	124.52	124.57	124.62	124.67	124.72	124.77	49.7
OMO	38.04	38.06	38.07	38.09	38.11	38.12	38.14	38.15	15.4
	124.82	124.87	124.92	124.97	125.02	125.07	125.12	125.17	50.6
OMK	38.17	38.18	38.20	38.21	38.23	38.25	38.26	38.28	15.7
	125.22	125.27	125.32	125.38	125.43	125.48	125.53	125.58	51.6
OMG	38.29	38.31	38.33	38.34	38.36	38.37	38.39	38.41	16.0
	125.64	125.69	125.74	125.79	125.84	125.90	125.95	126.00	52.6
OMD	38.42	38.44	38.45	38.47	38.49	38.50	38.52	38.54	16.3
	126.06	126.11	126.15	126.22	126.27	126.32	126.38	126.43	53.6

GEOPOTENTIAL ALTITUDE VERSUS CODE				SN FE39190		PAGE 31			AVERAGE RESOLUTION
				ALTITUDE: KILOMETERS KILOFEET					METERS FEET
	S	U	R	W	O	K	G	O	
OJS	38.55	38.57	38.59	38.60	38.62	38.64	38.65	38.67	16.7
	126.49	126.54	126.59	126.65	126.70	126.76	126.81	126.87	54.7
OJU	38.69	38.70	38.72	38.74	38.75	38.77	38.79	38.81	17.0
	126.92	126.98	127.03	127.09	127.15	127.20	127.26	127.31	55.8
OJR	38.82	38.84	38.86	38.87	38.89	38.91	38.93	38.94	17.4
	127.37	127.43	127.48	127.54	127.60	127.65	127.71	127.77	56.9
OJW	38.96	38.98	39.00	39.01	39.03	39.05	39.07	39.09	17.7
	127.83	127.88	127.94	128.00	128.06	128.12	128.17	128.23	58.1
OJJ	39.10	39.12	39.14	39.16	39.18	39.19	39.21	39.23	18.1
	128.23	128.35	128.41	128.47	128.53	128.59	128.65	128.71	59.4
OJK	39.25	39.27	39.29	39.30	39.32	39.34	39.36	39.38	18.5
	128.77	128.83	128.89	128.95	129.01	129.07	129.13	129.19	60.7
OJO	39.40	39.42	39.43	39.45	39.47	39.49	39.51	39.53	18.9
	129.25	129.32	129.38	129.44	129.50	129.56	129.63	129.69	62.0
OJQ	39.55	39.57	39.59	39.61	39.63	39.64	39.66	39.68	19.3
	129.75	129.81	129.88	129.94	130.00	130.07	130.13	130.20	63.5
OKS	39.70	39.72	39.74	39.76	39.78	39.80	39.82	39.84	19.8
	130.26	130.32	130.39	130.45	130.52	130.58	130.65	130.71	64.9
OKU	39.86	39.88	39.90	39.92	39.94	39.96	39.98	40.00	20.3
	130.78	130.85	130.91	130.98	131.04	131.11	131.18	131.25	66.5
OKR	40.02	40.04	40.07	40.09	40.11	40.13	40.15	40.17	20.8
	131.31	131.38	131.45	131.52	131.58	131.65	131.72	131.79	68.1
OKW	40.19	40.21	40.23	40.25	40.26	40.30	40.32	40.34	21.3
	131.86	131.93	132.00	132.07	132.14	132.21	132.28	132.35	69.8
OKO	40.36	40.38	40.40	40.43	40.45	40.47	40.49	40.51	21.8
	132.42	132.49	132.56	132.63	132.70	132.77	132.85	132.92	71.6
OKK	40.54	40.56	40.58	40.60	40.62	40.65	40.67	40.69	22.4
	132.99	133.06	133.14	133.21	133.28	133.36	133.43	133.50	73.4
OKG	40.71	40.74	40.76	40.78	40.81	40.83	40.85	40.88	23.0
	133.58	133.65	133.73	133.80	133.86	133.96	134.03	134.11	75.4
OKO	40.90	40.92	40.95	40.97	40.99	41.02	41.04	41.06	23.6
	134.18	134.26	134.34	134.41	134.49	134.57	134.65	134.73	77.5

GEOPOTENTIAL ALTITUDE VERSUS CODE SN FE39190 PAGE 32

ALTITUDE: KILOMETERS
KILOFEET

	S	U	R	M	D	K	G	C	AVERAGE RESOLUTION METERS FEET
OGS	41.09	41.11	41.14	41.16	41.19	41.21	41.23	41.26	24.3
	134.80	134.88	134.95	135.04	135.12	135.20	135.28	135.36	79.7
OGU	41.23	41.31	41.33	41.36	41.38	41.41	41.43	41.46	25.0
	135.44	135.52	135.61	135.69	135.77	135.85	135.93	136.02	82.0
OGR	41.48	41.51	41.53	41.56	41.59	41.61	41.64	41.66	25.7
	136.10	136.18	136.27	136.35	136.44	136.52	136.61	136.69	84.4
OGW	41.63	41.72	41.74	41.77	41.80	41.82	41.85	41.88	26.5
	136.78	136.86	136.95	137.04	137.12	137.21	137.30	137.39	87.0
OGD	41.30	41.93	41.96	41.98	42.01	42.04	42.07	42.09	27.4
	137.47	137.56	137.65	137.74	137.83	137.92	138.01	138.10	89.7
OGK	42.12	42.15	42.18	42.21	42.23	42.26	42.29	42.32	28.2
	138.19	138.28	138.38	138.47	138.56	138.65	138.75	138.84	92.6
OGG	42.35	42.38	42.41	42.43	42.46	42.49	42.52	42.55	29.2
	138.94	139.03	139.13	139.22	139.32	139.41	139.51	139.61	95.7
OGO	42.58	42.61	42.64	42.67	42.70	42.73	42.76	42.79	30.2
	139.70	139.80	139.90	140.00	140.10	140.20	140.30	140.40	99.0
ODS	42.82	42.85	42.98	42.92	42.95	42.98	43.01	43.04	31.3
	140.50	140.60	140.70	140.80	140.91	141.01	141.11	141.22	102.6
ODU	43.07	43.11	43.14	43.17	43.20	43.24	43.27	43.30	32.4
	141.32	141.42	141.53	141.64	141.74	141.85	141.96	142.06	106.3
ODR	43.33	43.37	43.40	43.43	43.47	43.50	43.54	43.57	33.7
	142.17	142.28	142.39	142.50	142.61	142.72	142.83	142.95	110.4
ODW	43.60	43.64	43.67	43.71	43.74	43.78	43.81	43.85	35.0
	143.06	143.17	143.28	143.40	143.51	143.63	143.75	143.86	114.8
ODD	43.88	43.92	43.95	43.99	44.03	44.07	44.10	44.14	36.4
	143.98	144.10	144.21	144.33	144.45	144.57	144.69	144.82	119.5
ODK	44.18	44.21	44.25	44.29	44.33	44.37	44.40	44.44	39.0
	144.94	145.06	145.18	145.31	145.43	145.56	145.68	145.81	124.6
ODG	44.48	44.52	44.56	44.60	44.64	44.68	44.72	44.76	39.7
	145.94	146.06	146.19	146.32	146.45	146.58	146.71	146.85	130.1
ODO	44.80	44.84	44.88	44.92	44.96	45.01	45.05	45.09	41.5
	146.98	147.11	147.25	147.38	147.52	147.66	147.79	147.93	136.1

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 12/13/77   SCOPE 3.4.4          * 0033544  A.F.G.L.
12.37.43.C0300II  FROM AC
12.37.43.IP   00000540 WORDS - FILE INPUT  , DC 80
12.37.44.CORD.
12.37.44.          2  6    CORDELLA
12.37.47.FTN,SL.
12.37.52.        .631 CP SECONDS COMPILATION TIME
12.37.52.LGO.
12.38.33.     STOP
12.38.33.      2.965 CP SECONDS EXECUTION TIME
12.38.33.OF   00014312 WORDS - FILE OUTPUT , DC 40
12.38.33.MS    17320  WORDS  (   21504 MAX USED)
12.38.33.CPA        4.144 SEC.          .060 COST
12.38.33.IO         1.426 SEC.          .012 COST
12.38.33.CM        69.399 KWS.          .048 COST
12.38.33.SS       COST OF JOB           .121
12.38.33.PP        11.046 SEC.      DATE 12/13/77
12.38.33.EJ   END OF JOB, AC
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Appendix D

A Method of Subtraction

1. THE METHOD

The circuit in Figure D1(a) was presented to the author by Mr. Hans Laping AFGL/LCC as a method of determining the difference between an unknown frequency, f_u (U events/second), and some fixed standard, f_s (N events/second), when the unknown is larger than the standard. A 1 sec sample of the signal of unknown frequency is applied to a counter which addresses an AND gate (G1). This gate detects a count equal to N events and sets a latch to "remember" the event. Gate G2 does the actual frequency comparison by passing any input signal which occurs after the Nth event is detected. Two types of outputs are available; a pulse of variable length if switch S is in the "a" position, or a number of pulses (U-N) if S is in the "b" position. In our case, the latter method is used and the pulses are counted as mentioned in Section 1 of the basic report.

2. THE DEDUCTION

As Mr. Laping uses a known period to measure an unknown frequency by subtracting a certain number of events, the author uses a known frequency to measure an unknown period and then subtracts some events. In the author's implementation, the AND gate (G1) is replaced with a ROM (which is wired as a diode AND circuit)

AD-A053 730 AIR FORCE GEOPHYSICS LAB HANSCOM AFB MASS F/G 1/3
AN AUTORANGING BALLOON ALTIMETER: A SINGLE PRESSURE TRANSDUCER --ETC(U)
JAN 78 R H CORDELLA

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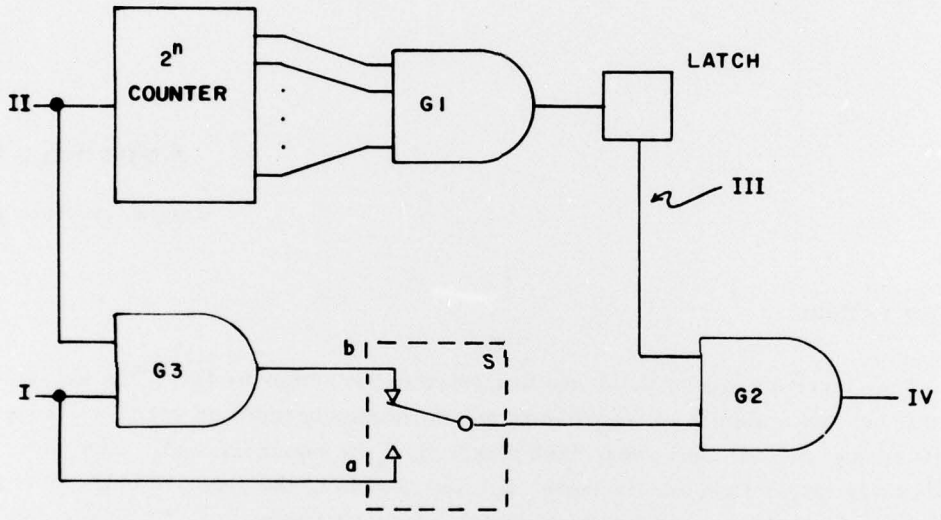
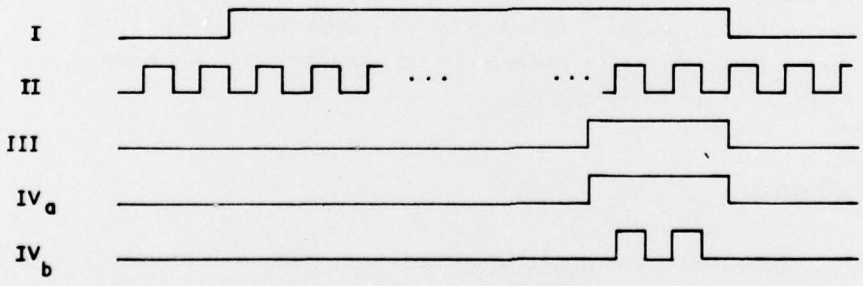
that has the advantage of programability. This lends the instrument flexibility to accept various (serial number) sensors without changing wiring. Each sensor has its own companion ROM which is placed into the circuit with the sensor.



a) BASIC SUBTRACTOR



b) CIRCUIT WAVEFORMS

Figure D1. Basic Subtractor Circuit

Appendix E

Programmable Calculator Flow Chart

Since there is a large number of programmable calculators available, only the Flow Chart of the point search program will be given (see Figure E1). It will work for any monotonic curve up to the fourth order and can handle a dummy variable z where

$$z = B_o + B_1 x \quad ,$$

and

$$y = A_o + A_1 z + A_2 z^2 + A_3 z^3 + A_4 z^4 \quad .$$

If the dummy variable z is not used, then $z = x$, $B_o = 0$ and $B_1 = 1$.

Figure E2 is an annotated curve for the application under discussion. The subscripts upper, u, and lower, l, are defined in terms of the dependent variable pressure, P, and then applied to the corresponding ordinate period ρ. In the program, the pressure of interest, P_i, is calculated as a function of the standard atmosphere. The two bounding points on the curve are chosen from the sensor manual and entered into the upper and lower registers for each variable. The program then halves the interval on the period axis until the P_n computed from a ρ_n is within the limit: ε of P_i.

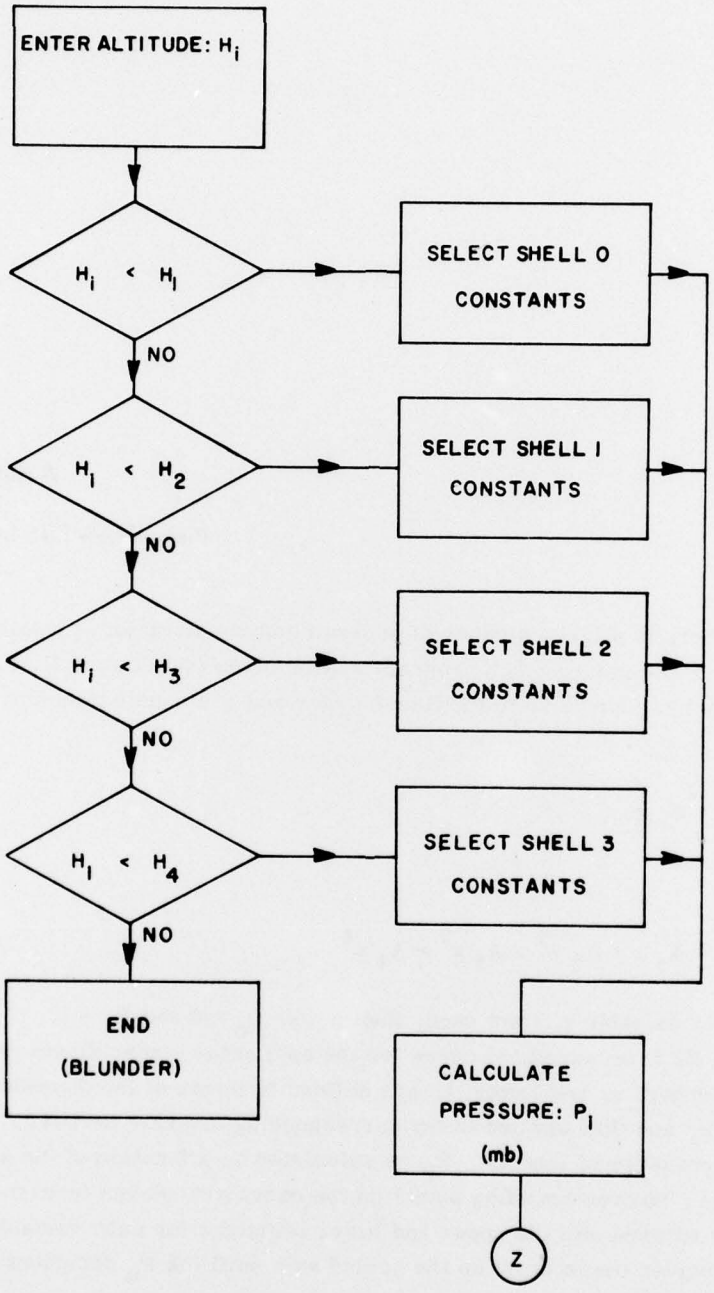


Figure E1a. Flow Chart

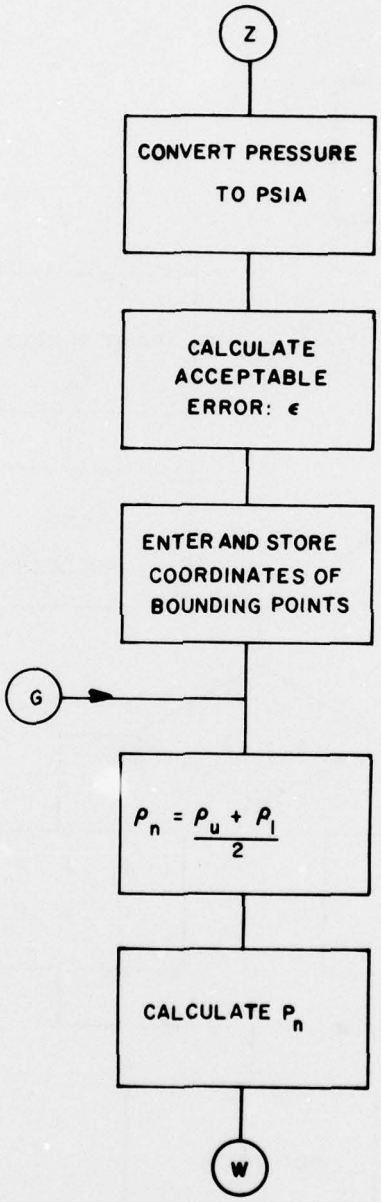


Figure E1b. Flow Chart

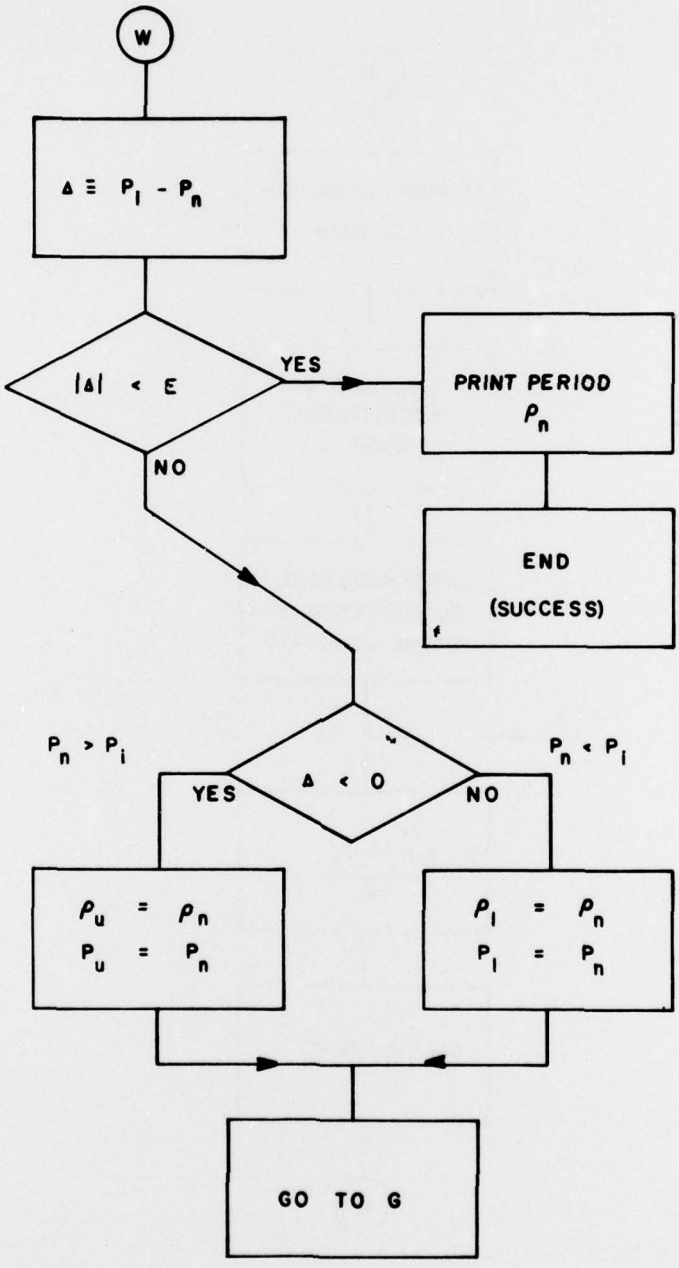


Figure E1c. Flow Chart

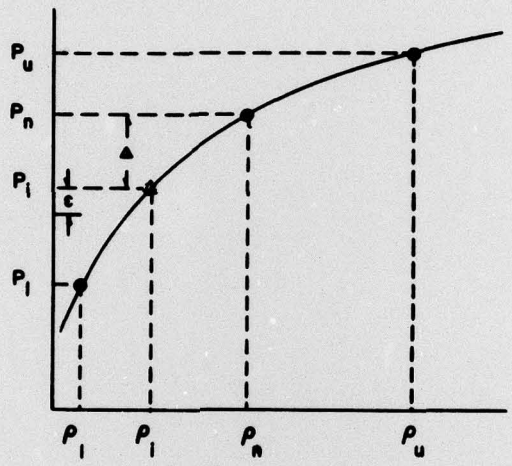


Figure E2. A Curve